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Arthropod Population Dynamics in Pastures Treated With Mirex-Bait to Suppress Red Imported Fire Ant Populations.

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Arthropod Population Dynamics in Pastures Treated with Mirex-Bait to Suppress Red Imported Fire Ant Populations

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ABSTRACT

Similar experiments were conducted in 1972 and 1973 in southern Louisiana to study the effects of single applications of mirex-bait (4.26 gram per hectare mirex) on arthropod communities of pastures. Frequencies of 53 arthropod categories were determined in the 1972 studies, and of 82 categories in the 1973 studies.

Both years, numbers of red imported fire ants, *Solenopsis invicta* Buren, were greatly reduced within 2 weeks following treatment. The effect was not uniform. The treated areas were repopulated by high numbers of *S. invicta* 2 months after treatment. Numbers of formicine ants, *Nylanderia* spp., were also reduced by the treatments.

Numbers of the following non-target arthropod taxa were higher ($P < 0.05$) in the mirex-treated than in the untreated pastures:

Taxon	Habitat sampled
(1972)	
Ant-like flower beetles, *Vacusus vicinus* (LaFerte)	Ground surface
Wolf spiders, *Lycosa riparia-helluo* complex	" "
Horn flies (pupae), *Haematobia irritans* (L.)	Cattle dung
Plant bugs, *Trigonotylus pulcher* Reuter	Herb layer
(1973)	
Sac spiders, *Trachelus deceptus* (Banks)	Ground surface
Ground beetles, Carabidae	" "
Horn flies (pupae), *Haematobia irritans* (L.)	Cattle dung
Chinch bugs, *Blissus insularis* Barber	Herb layer
Parasitic wasps, *Apanteles* spp.	" "
Big-headed flies, *Tomosvaryella* spp.	" "
Flesh flies, Sarcophagidae	" "

Numbers of the following non-target arthropod taxa were lower ($P < 0.05$) in the mirex-treated than in the untreated pastures:

Taxon		Habitat sampled
	(1972)	
Dung beetles, Aphodiinae		Cattle dung
Flea-beetles, Longitarsus sp.		Herb layer
	(1973)	
Wolf spiders, Schizocosa avida (Walkenaer)		Ground surface
Ambrosia beetles, Xyleborinus saxeseni (Ratzeburg)		" "
Rove beetles, Staphylinidae		" "
Dung beetles, Aphodiinae		" "
Crickets, Gryllidae		" "
Ponerine ants, Hypoponera opaciceps (Mayr)		Herb layer
Planthoppers, Fulgoroidea		" "
Parasitic wasps, Dryinidae		" "

Numbers of horn fly pupae in dung pats from a mirex-treated pasture were 4 times greater and numbers of Staphylinidae 15 times greater than in a comparable untreated pasture when cattle in both areas were not treated for control of horn flies ($P < 0.05$). Observations indicated that S. invicta preyed upon horn fly larvae and pupae. Where predation on horn fly immature forms was intense, Staphylinidae apparently were preyed upon as well. When numbers of horn fly pupae were low due to insecticidal treatment of cattle, differences between mirex-treated and untreated areas were less pronounced, or were not detected.

S. invicta apparently was indiscriminate in the arthropods attacked but most persistent and successful in exploiting immobile food sources, such as baits, and dead or relatively inactive arthropods. Thirteen species of ants occupied different niches of the pasture ecosystem.

INTRODUCTION

Although *Solenopsis invicta* Buren, known in the United States as the red imported fire ant, has become one of the most intensely studied ant species, much remains to be known of the inter-relationships between this ant and other arthropods.

As an introduced species, *S. invicta* has followed a pattern of explosive expansion in its new homeland. In recent times, numerous species of plants and animals have similarly invaded new lands (Elton 1958). Much effort has been expended in attempts to quell some of these invasions but seldom have these efforts been successful.

S. invicta is both a scavenger and a predator. The ant preys upon both beneficial and destructive insects. Its role in sugarcane fields is regarded as beneficial because it reduces damage by the sugarcane borer, *Diatraea saccharalis* (F.) (Hensley, et al. 1961; Negm and Hensley 1967, 1969; Reagan, et al. 1972). It benefits livestock by preying upon the lone star tick, *Amblyomma americanum* (L.) and apparently is a major factor in suppressing populations of this tick (Harris and Burns 1972). It is suspected that the species is similarly beneficial in a number of other crops.

Some evidence is available that *S. invicta* affects populations of non-pest arthropod species, including decomposers and predators (Wilson and Oliver 1969; Whitcomb, et al. 1972; Reagan, et al. 1972; Roe 1974). It has been suggested that *S. invicta*, by simplifying arthropod communities of agroecosystems through predation, could tend to undermine whatever degree of stability they may possess (Whitcomb, et al. 1972). According to this view, the beneficial effects of *S. invicta* in controlling certain pests could be offset to some degree by undesireable ecological consequences over the long run.

A related problem is that of the ecological effects of the insecticidal treatments used to suppress _S. invicta_ populations.

The present study was undertaken with the primary objective of comparing arthropod populations in pastures supporting high numbers of _S. invicta_ with those of pastures free of the species. The taxa chosen to be studied were the important epigeal (ground-inhabiting) arthropod species, certain insect taxa associated with cattle dung, and arthropod taxa associated with the herb layer. It was intended that the study would reveal any beneficial role played by the ant's predatory activities in these pastures, as well as any ecologically destructive consequences of this predation.

To obtain areas free of _S. invicta_, pastures were treated with mirex-bait. Methods and rates of treatment employed by public control agencies were used. Thus, a secondary objective of the study was to monitor the impact of this type of treatment on the arthropod ecology of pastures.

In addition to sampling arthropod populations in treated and untreated areas, observations of the behavior of ants and other insects were made with the objective of refining knowledge of the relationships between _S. invicta_ and other arthropods of pastures.

REVIEW OF LITERATURE

Taxonomic Status

Two species of imported fire ants are known to be established in the United States, *viz.*, the black imported fire ant, *Solenopsis richteri* Forel, and the red imported fire ant, *Solenopsis invicta* Buren. Previous to Buren's (1972) description of *S. invicta* both species of imported fire ants were regarded as infraspecific forms of a single species that was variously referred to as *Solenopsis saevissima* (F. Smith) or *Solenopsis saevissima richteri* Forel. In literature published prior to Buren's description, the dark and light (red) forms of the imported fire ant refer to *S. richteri* and *S. invicta*, respectively. Where neither form was specified, the species is likely to have been *S. richteri* in literature published prior to 1940. The red form was the species that invaded 9 states and brought on large scale emergency measures to control or eradicate it (Brown 1961). Therefore, most references to imported fire ants published after 1940 refer to *S. invicta*. Studies of imported fire ants in South America prior to Buren's revision may refer to any of several species of the *Solenopsis saevissima* complex.

The synonomy of the 2 species was given as follows (Buren, 1972):

Solenopsis richteri Forel

S. pylades var. *richteri* Forel, Deutsche Ent. Zeitschr., p. 267 (1909).

S. geminata subsp. *saevissima* var. *richteri*: Wheeler, Bull. Amer. Mus. Nat. Hist. 34: 297 (1915).

S. saevissima var. *richteri*: Santschi, Physis Buenos Aires 2: 381 (1916).

S. (*Solenopsis*) *saevissima* var. *richteri*: Creighton, Proc. Am. Acad. Arts Sci., 66: 87 (1930).

S. saevissima richteri: Wilson, Mem. Ins. Oswaldo Cruz, 50: 66 (1952).

S. saevissima: Ettershank, (in part), Aust. Jour. Zool., 14: 143 (1966).
S. richteri: Buren, Jour. Ga. Entomol. Soc. 7 (1): 4 (1972).

Solenopsis invicta Buren

S. saevissima saevissima X saevissima richteri: Wilson, Mem. Ins. Oswaldo Cruz, Vol. 50, p. 65 (1952).
S. invicta Buren, Jour. Ga. Entomol. Soc. 7 (1): 9 (1972).

Ecology of Imported Fire Ants. 1. Food and Foraging Habits.

According to a number of earlier reports of the food habits of imported fire ants, the species damaged crops and killed wildlife and domestic animals. A number of vertebrate animal species, including ground nesting birds, squirrels, rabbits, pigs, calves, and poultry had been attacked by imported fire ants. Many crop plants, particularly okra, were reported to have been attacked (Anonymous 1958). Imported fire ants were reported to be injurious to young corn plants, to strip bark from citrus, and to kill newborn livestock (Lyle and Fortune 1948). The first evidence of damage to young corn plants by imported fire ants was in 1935 in Alabama. Attacks on germinating corn seed and tender plants had been frequent since then (Eden and Arant 1949). Wilson (1951, 1958, 1959) reported that imported fire ants damaged many crops.

Damage to crops and livestock by S. invicta was seldom reported after 1958. Markin (1970) was of the oppinion that increased use of chlorinated hydrocarbon insecticides in crops in recent years reduced damage by ants. Bellenger, et al. (1965) considered the reports of crop and livestock destruction by the ant to be based on isolated occurrences.

Studies involving more detailed observations of the activities of S. invicta in the field characterized them as omnivorous, with a preference for arthropods. Green (1952) noted that imported fire ants attacked and ate many insects, tended mealybugs and aphids, and ate seeds and juices of many plants. Mason (1957) made observations of imported fire ants carrying material to nests. During daylight hours, about 27 to 54 workers per hour passed a point along a foraging tunnel, travelling towards the nest. About one fourth of the workers appeared to be carrying food. About 8 tunnels radiated from a single nest. He observed that arthropods, gathered dead or captured alive, constituted the foraging material of the ants. The only plant material which the ants were observed to consume was honeydew from ergot bodies produced by a fungus infecting Paspalum seeds. Foraging activity seemed to be greatest in the spring, and leveled off in summer. It was usually during the summer that the ants were observed to tend aphids and coccoids, rather than at other seasons. He reported that an apiculturist had told him that imported fire ants entered bee hives and preyed on wax moth larvae but did not prey upon immature bees.

In Argentina the food of imported fire ants (probably S. richteri) was found to consist mostly of insects. One observer interviewed reported to have counted about 100 different species of insects stored by the ants in a single nest. Since some species of insects regarded as harmful by the Argentineans had been observed in the forage material, the ants were considered beneficial in that country. Except for occasional seeds, the fire ants did not feed upon plant material, and no attacks upon livestock had been reported (Hays 1958).

A variety of insect species was found stored in nests of imported fire ants in the United States. Insects of 28 species were placed in cages near nests. All were killed and carried whole or in pieces to nests, except for a large grasshopper that eluded capture. The material that was brought by ants to nests consisted of arthropods or their parts, a preference being noted for small insects and larval forms. Ants foraged in cattle dung and captured larvae of Diptera. The ants were not observed to forage plant material in the field and no evidence of damage to plants was observed in the area. Of 18 plant species grown from seed in nests in the laboratory, only okra plants were damaged. None of 18 species of seedling plants transplanted into mounds were damaged. Of dry, and germinating seeds of 17 plant species, only dry peanuts, and germinating peanuts, corn, and okra seeds were eaten. Insects, dead or alive, were preferred over any other material offered (Hays and Hays 1959).

Much of the information reported by Green (1967) concerning foraging of imported fire ants is similar to Mason's (1957) observations. Green added that ants were able to attack and kill apparently healthy insects, including large, active forms such as grasshoppers and 1 to 2 inch long caterpillars. Johnson and Hays (1973) observed imported fire ants, Solenopsis sp., foraging near a wet pond margin. The ants killed and ate a Tabanus larva measuring 3 cm. long.

The impact of S. invicta on major pests of soybeans appeared to be intense, with almost all stages of the insects being attacked. On 4 separate occasions, over 40 pupae of the velvetbean caterpillar, Anticarsia gemmatalis Hübner, formed under pitfall trap lids, were attacked by S. invicta. The ants removed numerous soybean loopers, Pseudoplusia includens (Walker), green cloverworms, Plathypena scabra (Fabricius), and corn earworms, Heliothis zea (Boddie) from soybean foliage. Collections of material carried by ants showed that it consisted mostly of insects and occasionally of seeds of *Paspalum* species. The ants tended soft scales and mealybugs on weeds and grass roots (Whitcomb, et al. 1972).

In an intensive study in Louisiana, items brought to nests by *S. invicta* workers were indentified to as low a taxonomic category as possible, or placed in a category of unidentified fragments. The items foraged during the day and night in pastures, and during the day in cut-over loblolly pine stands were essentially similar. Of the identified items, only 1 to 4 percent were plant seeds. All other items were invertebrate animals or their parts. The taxa represented in the foraging material may be summarized as follows: Phyla: Annelida, Mollusca, Arthropoda; classes of Arthropoda: Isopoda, Diplopoda, Chilopoda, Arachnida, and Insecta. Members of 28 families of Insecta were represented. Most of the items in the foraged material were distributed fairly evenly among the taxa. Higher numbers of some taxa, *e.g.*, Annelida, Araneae, and Collembola were observed among the foraged items. These numbers may have represented to some extent numbers of parts, rather than numbers of whole insects. Since about half of the material consisted of unidentified material and a portion of the workers may have been carrying liquid food not identified as any item, the diversity of materials collected by *S. invicta* may have been even greater than shown by the data (Wilson and Oliver 1969).

A number of studies of imported fire ants in the laboratory, or otherwise under artificial conditions of supplied artificial food, have contributed to a knowledge of the food habits of imported fire ants, and their adaptations for obtaining food. Many of these studies were undertaken with the objective of developing baits for insecticidal formulations.

In the laboratory, imported fire ants have been reported to feed on a wide variety of plant and animal substances (Anonymous 1958; Hays and Arant 1960; Bartlett and Lofgren 1961; Lofgren, et al. 1964; Khan, et al.

1967). In such studies, a preference for oil was observed. Imported fire ants showed definite preferences among 12 kinds of animal oils and 25 vegetable oils (Lofgren, et al. 1964). The lipid fraction of insects was found to be highly acceptable to imported fire ants. Linoleic and linolenic acids and their glycerol and phospholipid esters were the chief phagostimulants in the lipid fractions. The general order of preference of foods in descending order was oils, carbohydrates, and proteins and amino acids (Vinson, et al. 1967). S. richteri showed differing gustatorial responses to different electrolytes in water at concentrations between 1 mM and 100 mM (Vinson, 1970). Specimens of 16 taxa of arthropods were frozen and placed near ant colonies in the field. Species of spiders, spittlebugs, carabids, katydids, and cucumber beetles were found to be especially attractive, while stink bugs, ants, and adult house flies were rejected. Laboratory studies were conducted by crushing specimens on filter paper and offering it to laboratory colonies. Grasshoppers, spiders, dragonflies, and spittlebugs were preferred. Ants and leafhoppers were least attractive. Various water-soluble compounds were offered. The results indicated that acceptance of food by imported fire ants may be influenced by the presence or absence of water-soluble substances, of which leucine may be important (Ricks and Vinson 1970). In studying the distribution of foods in colonies by means of foods tagged with dyes, Vinson (1968) found that oils were more evenly distributed among the castes than were carbohydrates or proteins. More sugar solution was consumed than oil, but was regurgitated or excreted at a faster rate. All castes contained a greater percentage of oil than either sugar or protein. Protein was consumed less, and principally by the larvae.

The digestive enzymes of S. invicta apparently are consistent with their preference for lipids. Lipase was reported to be produced in the mandibular and salivary glands, and in the fore-, mid-, and hind-gut of major workers. The distribution of amylase, invertase, and protease was reported to be more restricted. Protease was especially limited (Ricks and Vinson, 1972).

Certain carbohydrates associated with an ascomycete infecting the seeds of Paspalum dilatatum Poiret were attractive to imported fire ants, rather than fractions of the seeds themselves (Vinson 1972). Mason (1957) reached the same conclusion based on field observations.

Large S. invicta workers store liquid food in their crops and thus may be able to provide food for the brood or other workers during periods when food is limited (Glancey, et al. 1973).

Imported fire ants detect low thresholds of trail substance and carbon dioxide (Wilson 1962, 1971). Their color perception is similar to that of bees, cockroaches, and a number of other insects that have been studied (Marak and Walker 1965). Wheeler (1910) stated that ants in general utilize olfactory, gustatory, and tactile perception to a greater degree than visual perception, and are unable to see small objects such as insects at distances of a few milimeters, but perceive large objects further away. They apparently perceive moving objects more clearly than stationary objects

S. invicta does little or no foraging during the winter in the United States. Rhoades and Davis (1967) reported that in northwest Florida foraging activity peaked in April, August, and October, with the highest peak in August. The ants foraged most actively after rains.

Among ants studied in Poland (Dobrzanska 1958), certain species of the subfamily Formicinae tended to exploit fixed food sources such as honeydew-secreting insects. Trails from nests to these sources were maintained for long periods of time, and the ants defended small areas around these sources from ants of other colonies. Among the subfamily Myrmicinae were species that were opportunistic in their foraging habits. Individual workers foraged for temporary food sources, recruiting nestmates as necessary. Fire ant species of the genus Solenopsis are exceptional in that they employ both methods of foraging (Wilson 1971). Thus, they take possession of stable food sources and in addition most of a large area surrounding the nest.

During the first stages of the invasion of an uninhabited area by Solenopsis invicta, 100 to 150 small nests may be established per acre. As the colonies develop in size, the stronger ones conquer the weaker ones until the nests per acre level off at about 15 to 40 colonies per acre. These mature colonies contain from 10,000 to 40,000 ants, mostly workers who patrol the territories up to the boundaries of neighboring territories (Wilson, et al. 1971). Eisenberg (1972), using nearest neighbor analysis, found that nests have a highly regular spacing pattern, rather than a random or clumped pattern. He attributed this to the intense competition between colonies for territory.

Mass foraging and recruitment in S. invicta was described by Wilson (1962). Workers wander at random outside the nests, orienting themselves by light sources. Upon discovering a food source, a worker may recruit nestmates to assist in transporting the material to the nest. The worker travels toward the nest and returns to the food source, depositing from its sting apparatus a trail pheromone which stimulates trail following behavior in other workers. The workers that arrive at the food source begin carrying food to the nests, depositing additional pheromone along a common trail, so that still more workers are recruited to the food source. When an excessive number of ants has been mustered at a food source, additional ants are not able to find room to work and so wander off without laying trails. Thus, an equilibrium is maintained. Individual ants can control the amount of pheromone deposited proportional to the attractiveness of the food source (Hangartner, 1967).

Stratton and Coleman (1973) studied the behavior of imported fire ants in mazes with glass floors. Workers were disturbed when the glass floors were changed, thus eliminating their pheromone trails, but were capable of using kinesthetic, visual, and tactile cues to find food sources.

Solenopsis _invicta_ captures prey by seizing it with the mandibles and injecting venom by means of a sting apparatus located at the tip of the abdomen. The formicid sting is morphologically homologous with the primitive insect ovipositor. It is well developed for defense and capturing prey in the Ponerinae, Pseudomyrminae, Dorylinae, and in most Myrmicinae, all of which are primitive subfamilies of the Formicidae. In more advanced subfamilies the sting is vestigeal or absent. There is a tendency among the more primitive ants to subsist largely on diets of arthropods (Wheeler 1910). _S. invicta_ is in the subfamily Myrmicinae. The venom of the sting is insecticidal (Blum, et al. 1958), and it is impressive to observe the fierceness and efficiency by which these ants capture prey. An observer must be cautious, however, that such observations do not lead to exaggerated ideas of the ecological effects of the ant's predation. _S. invicta_ is a scavenger as well as a predator, and the relative importance of scavenging _versus_ predation in the foraging activities of the ant has never been fully evaluated quantitatively. A great many factors are likely to influence this ratio.

The work reviewed up to this point pertained to food and foraging habits of imported fire ants. With the knowledge that their food consisted largely of insects and spiders, attempts were made to determine whether they regulated or otherwise influenced populations of other arthropods. There were reports that pest populations increased in crops in Louisiana where fire ants had been controlled (Long, et al. 1958; Newsom, et al. 1960; Hensley, et al. 1961; Charpentier, et al. 1967). Since the ants had been controlled using broad-spectrum insecticides, there was a reduction of many non-target species along with the imported fire ants. The individual role of *S. invicta* in regulation of the pest species could not be assessed. However, in additional studies employing insecticides to suppress imported fire ant populations a variety of techniques was used to attempt to assess the effects of the ant's predation on other arthropods.

Negm and Hensley (1967) published a list of predators collected in Louisiana sugarcane fields which included species of Coleoptera, Dermaptera, Araneae, and 6 species of ants. Field observations of predation and correlation studies indicated that ants were among the most important members of the predator complex. Heptachlor suppressed this predator complex, resulting in increased damage to sugarcane by the sugarcane borer, *Diatraea saccharalis* (Fabricius). Evaluation of mortality factors of borer egg masses and larvae placed in treated and untreated plots revealed that predation was higher in untreated plots than in treated plots and that sucking predators were more important than chewing predators in the destruction of eggs (Negm and Hensley 1969).

Prior to the study of Reagan, et al. (1972) increases in damage by sugarcane borers due to imported fire ant control had involved the use of granular heptachlor or dieldrin, insecticides well-known to have broad spectra of activity. They applied mirex-bait for suppressing fire ant populations and azinphosmethyl for controlling sugarcane borers. Pitfall trap collections in treated and untreated plots showed that red imported fire ant, cricket, ground beetle, and rove beetle populations were suppressed by the mirex-bait treatment, but spider populations were not. Sugarcane borer populations increased ealier in the season, and azinphosmethyl was less effective in controlling damage by the sugarcane borer in plots where mirex-bait had been applied.

Gross and Spink (1969) reported that imported fire ants fed upon eggs of striped earwigs, Labidura riparia (Pallas), that were placed in vials in the field and that female earwigs were often ineffective in protecting their eggs from imported fire ants. They sampled populations of L. riparia in areas treated with heptachlor, mirex-bait, and untreated plots. They found significantly higher numbers of L. riparia in plots treated with heptachlor than in plots treated with mirex-bait or untreated plots. Their explanation for these results was that populations of L. riparia increased where the heptachlor treatements eliminated the ant populations, while the mirex treatment was effective for only a short time, after which the ants entered the treated areas to forage.

Leafhoppers were reported to increase in areas treated with heptachlor for imported fire ant suppression. In rice fields, populations of the rice stink bug, Oebalus pugnax (Fabricius), were increased 4 times those of untreated areas, and leafhoppers of the genus Draeculacephala were increased 30 times (Newsom, et al. 1960). In pastures where heptachlor had resulted in increased leafhopper populations, a reduction of spiders as well as of imported fire ants had occurred (Wilson, 1969)

Wilson and Oliver (1970) reported that imported fire ants took larvae and pupae of Nantucket pine tip moths, Rhyacionia frustrana (Comstock) from small pine trees. They treated small plots with heptachlor and compared larval and pupal populations of R. frustrana in treated and untreated areas during 2 summers. They also sampled arboreal populations of imported fire ants and spiders and determined the numbers of active and inactive imported fire ant colonies in treated and untreated areas. Although the spider and imported fire ant populations were reduced by the treatments, the larval and pupal populations of R. frustrana remained about the same in treated and untreated areas.

Rhoades (1962, 1963) chose 3 areas in northwest Florida of about 1280 acres each. After arthropod populations in the 3 areas had been sampled for a year, 1 area inhabited by imported fire ants was treated with heptachlor. The other 2 areas, 1 of which was inhabited by imported fire ants and 1 of which was not, were left untreated. No striking differences were detected in populations of 14 species of insects captured in light traps; Annelida and 1 insect species in soil samples; 2 insect species in litter samples; and 2 species in sweep net collections. Araneae, Annelida, and 6 species of insects collected pitfall traps were severely reduced by heptachlor treatments, but this effect was temporary. Rhoades concluded that imported fire ants had little effect on other insect species.

Harris and Burns (1972) used a variety of techniques to determine if S. invicta was an important natural enemy of the lone star tick, *Amblyomma americanum* (L.), which had become less common in parts of Louisiana that had been invaded by *S. invicta*. In different tests, they placed eggs and engorged larvae of *A. amblyomma* in carton lids in areas treated with mirex-bait and in untreated areas, and found that after 24 hours numbers of tick eggs were significantly reduced in the untreated areas compared to the mirex-bait treated areas, and numbers of larvae were significantly reduced after 24, 48, and 72 hours of exposure. Engorged female ticks placed in treated areas were attacked within 3-1/2 hours after exposure and after 48 hours no ticks remained in cages in untreated areas, while in the treated areas the caged ticks remained undisturbed by predators. About 5350 engorged tick larvae were released in treated and untreated plots in April. In June, 188 were recovered from the mirex-treated area and none from the untreated area. Of about 3500 engorged tick nymphs released in August and September in treated and untreated plots, 2515 adult ticks were recovered in March in the treated areas and none in the untreated areas. They did not rule out predation by spiders and other predators, but concluded that the major cause of decline in tick populations was very probably predation by *S. invicta*.

In regard to the beneficial role played by *S. invicta* in relation to certain crops, it is interesting to note the the closely related southern fire ant, *S. xyloni* McCook, was referred to as the cotton ant nearly 100 years ago, and was considered a beneficial insect in that crop due to predation on the "cotton-worm", probably *Alabama argillacea* (Hübner) (McCook 1882).

2. Interspecific relationships between Solenopsis invicta and other species of ants.

It has been widely recognized that the principal enemies of species of ants are generally ants of other colonies or species. In the conflicts between ants, it is often difficult to draw a distinction between predation and competition. Therefore, the special interspecific relationships between ants will be dealt with as a separate topic.

In general, species of ants that are closely related taxonomically are those most likely to be ecological equivalents, and hence are more likely to come into conflict (Wilson 1971, and contained references). Thus, S. invicta has replaced the southern fire ant, S. xyloni over much of its range and has largely replaced the tropical fire ant, S. geminata (F.), where the latter has come into conflict with S. invicta in pastures and other open areas (Wilson and Brown 1958; Wilson 1971). S. geminata, however, is apparently able to compete with S. invicta in many of the areas of the central uplands of Florida (Buren, et al. 1974). Although S. richteri Forel was the first of the 2 imported fire ants reported in the Mobile, Alabama, area, S. invicta is the only imported fire ant collected in that locality at the present. Apparently, S. invicta has replaced S. richteri. However, S. richteri has been slowly increasing its distribution in northern Mississippi. S. invicta has apparently replaced the Argentine ant, Iridomyrmex humilis Mayr, in many areas of the southern United States (Buren, et al. 1974).

Green (1967) stated that the imported fire ant was an enemy of the native ant populations. Hensley, et al. (1961) found the following ant species in Louisiana sugarcane fields: Solenopsis invicta, S. xyloni, I. humilis, Pheidole dentata Mayr, Ponera opaciceps Forel, Ponera trigona var. opacior Forel, and Pheidole sp. Negm and Hensley (1967) reported Ponera opaciceps, Paratrechina melanderi Wheeler, Strumigenys louisianae Roger, Monomorium sp. and S. invicta in sugarcane fields. Reagan, et al. (1972) reported collecting only S. invicta in a Louisiana sugarcane field and stated that ant species other than S. invicta disappeared from these habitats when invaded by the latter species.

Whitcomb, et al. (1972) made collections and observations on species of ants in fields throughout the soybean growing regions of northern Florida. Species of the subfamily Myrmicinae were important in these communities. They reported that S. invicta appeared to be the most aggressive ant species in these fields. Twelve to 15 species were collected in fields where S. invicta had not become established, while in fields inhabited by S. invicta only 5 or 6 species could be found. Ant species that appeared to be severely affected by S. invicta were Pheidole morrisi Forel, Iridomyrmex pruinosus (Roger), Solenopsis geminata, and the black form of Conomyrma pyramicus (Roger). On the other hand, the yellow form of Conomyrma pyramicus (Roger), Pogonomyrmex badius (Latreille), Cyphomyrmex rimosus minutus Mayr, Trachymyrmex septentrionalis (Wheeler), and species of Nylanderia appeared to coexist with S. invicta. Cultivation was the most important single agricultural practice affecting ant populations. As a result, a majority of the ant species did not nest in soybean fields, but foraged in from turn rows. They suggested that the most important single biotic factor other than food availability affecting species populations in soybean fields was perhaps the presence or absence of S. invicta.

Roe (1974) used a bait sampling technique to study the relative abundance of ant species in relation to S. invicta at the fringe of its range in Arkansas. Solenopsis xyloni was replaced by S. invicta as the latter species extended its range along this fringe line. Sixty-two other ant species were collected in the study area. Roe considered 13 of these species to be affected in varying degrees by S. invicta. The data for some species are ambiguous, but it is of interest that Nylanderia melanderi arenivaga (Wheeler) seemed to thrive in areas where S. invicta was established.

Nylanderia melanderi arenivaga (Wheeler) and Solenopsis molesta (Say) were observed to establish colonies in nests of S. invicta and prey upon eggs of the latter. Both of these species appear to possess adaptations that permit them to avoid conflict with S. invicta (O'Neal, 1974). It seems probable that a phenomenon is involved such as that reported by Hoelldobler (1973) who studied Solenopsis fugax Latreille and Monomorium pharaonis (L.) in Germany. These are tiny thief ants similar in some respects to S. molesta. While preying upon the broods of other species, they discharge repellents which prevent the victimized ants from protecting their broods.

In laboratory studies of conflicts between S. invicta and Lasius neoniger Emery, workers of the latter species could destroy 2 to 3 S. invicta workers for every L. neoniger worker destroyed. But in the field, S. invicta generally overcame L. neoniger because of its superiority of numbers (Bhatkar, et al. 1972).

No studies of the relationships between S. invicta and other ant species in South America have been published. Allen, et al. (1974) suggested that species of Pheidole, which are predominant in the original homeland of S. invicta, may influence the distribution of the latter species in South America.

Ant queens are vulnerable to attack by other insects during nuptial activities and when searching for sites in which to found colonies. Ant species that have been recorded as destroying queens of S. invicta are Conomyrma pyramicus (Roger) (Fincher and Lund 1967; Whitcomb, et al. 1972); Conomyrma insana (Buckley)(Markin, et al. 1971; Whitcomb, et al. 1973); Lasius neoniger Emery (Whitcomb, et al. 1972, 1973); Pheidole dentata Mayr and P. morrisi Forel (Whitcomb, et al. 1972).

3. Other relationships between Solenopsis invicta and other arthropods.

In addition to predator-prey relationships between S. invicta and its prey, and the special interspecific relationships involving aggression and competition between S. invicta and other ant species there are reports in the literature concerning other kinds of ecological relationships between S. invicta and other arthropods.

Collins and Markin (1971) published a list of 52 species of arthropods that they collected from 116 nests throughout the southeastern United States. One species each of Myrmecaphodius (Scarabaeidae), Myrmecasaurus (Staphylinidae), Thysanura, and Uropodidae (Acarina) were found frequently in the nests, and appeared to have symbiotic relationships with S. invicta. The other species collected in the nests apparently occurred there incidentally.

Relationships between S. invicta and honeydew-secreting insects has been observed, but little attention has been given to this aspect of the ant's ecology (Green 1967; Hays and Hays 1959; Whitcomb, et al. 1972).

Several species of spiders of the families Therididae, Gnaphosidae, and Thomisidae were reported to capture workers of _Solenopsis_ species. A species of Salticidae observed in the laboratory was well adapted to capturing workers of many species of ants, including those of _S. invicta_ (Edwards, et al. 1974).

Several species of spiders have been observed to attack queens of _S. invicta_ while the latter were exposed above ground. Several species of dragonflies capture alates of _S. invicta_ in flight (Markin, et al. 1971; Neal and Whitcomb 1972; Whitcomb, et al. 1973; Roe 1974). A tiger beetle, _Cicindella punctulata_ (Oliver), and the striped earwig, _Labidura riparia_ (Pallas) attack queens. The earwig has been observed to dig underground to attack the queen in its brood cell (Whitcomb, et al. 1973). Roe (1974) observed a species of Mantidae, _Stagmomantis carolina_ (L.) and a robber fly, _Efferia apicalis_ attacking _S. invicta_ alates.

Parasitic insects associated with the _Solenopsis saevissima_ complex in South America have been studied by several authors. These studies were reviewed by Williams and Whitcomb (1973).

Mirex and its Toxicity to Arthropods.

Mirex is the trade name for Dodecachloro-octahydro-1,3,4-metheno-2H-cyclobuta (cd) pentalene. It has a broad spectrum of activity to arthropods of different taxonomic groups. A characteristic feature is its delayed toxicity. It is practically insoluble in water, and highly persistent.

Crustaceans. Mirex was not lethal to crayfish exposed to dosages as high as 0.1 ppm for 72 hours (Muncy and Oliver 1963). However, in juvenile crayfish exposed to 1 ppb of mirex for 144 hours, mortality approached 100 percent after 5 days. When 10 granules of mirex-bait (0.3 % AI) were placed in 2 liters of water with crayfish, over 90% mortality was reached in 7 days. One granule of mirex-bait was fed to each of 108 crayfish. Fifty-five percent mortality was reached in 3 days (Ludke, et al. 1971). Exposure to mirex under laboratory conditions affected various species of shrimps and crabs. Fiddler crabs were observed to pick up mirex-bait and ingest it, resulting in mortality. Juvenile blue crabs died after eating grass shrimp fed 1 particle each of mirex-bait (Lowe, et al. 1971). Concentrations of mirex in the parts per billion affected larval development and survival of 2 species of crabs (Bookhout, et al. 1972). Following treatment of coastal areas in attempts to eradicate imported fire ants, Borthwick, et al. (1973) found mirex residues of 0-6 ppm in crabs and 0-1.3 ppm in shrimps but observed no mass mortalities. Hyde, et al. (1972) investigated the effects of 3 applications of 4X mirex bait, each at a rate of 1.25 pounds per acre, on crayfish in field plots. Crayfish plots were sampled about 8 months after the first mirex-bait application, and 1 month after the last application. Significantly lower numbers of crayfish occurred in plots treated only with mirex-bait compared to untreated plots. However, the numbers of crayfish in plots treated with mirex-bait, malathion, and carbofuran differed little from the numbers in untreated plots. Orthagonal comparisons indicated that the mirex did not reduce crayfish numbers. However, high levels of mirex residues were found in the crayfish.

Insects. Mirex formulated as a wettable powder reduced damage to leaves of tobacco by the tobacco flea beetle, Epitrix hirtipennis (Melsheimer), according to Dominick (1965). Mirex at the rate of 1.17 pounds per acre (AI) reduced damage to cotton by the cotton bollworm, Heliothis zea (Boddie) and cotton boll weevil, Anthonomus grandis (Boheman), according to Cowan and Davis (1963). When fed to rats and rabbits, mirex at a dosage of 0.06 % in food acted systemically, killing fleas, Xenopsylla cheopis (Rothschild), that infested the animals (Clark and Cole 1968; Clark, et al. 1971). Black carpet beetles, Attagenus piceus (Oliver) and furniture carpet beetles, Athrenus flavipes LeConte were reduced 93 % in 14 days by pre-soaking fabric in acetone solution of 0.06 % mirex (Pence and Viray 1965).

Mirex-bait applied at 1.24 pounds AI per acre for control of the cribate weevil, Brachyrhinus cribricollis (Gyllenhal), a pest of broccoli and strawberries, was slow-acting compared to several other insecticides tested, but achieved 100 % control within 8 days (McCalley 1967). Bahia grass pastures infested with a cerambycid, Derobrachus brevicollis Serville, were treated with granular mirex at 2 pounds AI per acre and mirex-bait at 0.15 pounds AI per acre. Seven months later, both types of treatment were found to be effective in reducing numbers of D. brevicollis (Morgan and Tippins 1967). Mirex-bait disked into the soil to a depth of about 4 inches appeared to be promising in controlling subterranean larvae of the southern potato wireworm, Conoderus falli Lane (Day and Crosby 1972). Mirex incorporated into apple pomace or wheat bran bait was readily consumed by larvae of the black cutworm, Agrotis ipsilon (Hufnagel). Eighty percent control was achieved (Sechriest 1968). Fish-flavored cat food with 0.5 to 1 % mirex was found to be effective in controlling yellowjackets, Vespula spp., according to Wagner and Reierson (1969). Wooden blocks partially decayed by a brown-rot fungus were used as baits for eastern subterranean termites, Reticulitermes flavipes (Kollar). The blocks were dipped in 1 % solution of mirex in toluene and set in the ground. Over a 12-month period, attacks on the blocks subsided to a low level, compared to blocks not treated with mirex (Esenther and Gray 1968). Wooden blocks pressure-treated to retain mirex were attacted less by termites than untreated blocks over a 3-year period (Esenther and Beal 1974). A termite, Cornitermes cumulans (Kollar) was controlled with 450 mirex-bait (Bastos Nogueria, et al. 1971). House flies kept in glass containers with mirex residues, and flies fed small amounts of mirex in the diet, were susceptible to mirex. The effect was characteristically delayed, compared to other organochlorines (Plapp 1973). According to a report by the Allied Chemical Company (Anonymous 1971), mirex controls earwigs.

Four formulations of mirex-bait used in ant control are shown in Table I. Harris (1971) reported reductions of S. invicta, spiders, crickets, and rove beetles following 2 applications of 4X mirex-bait at 1.25 pounds per acre each at Pineville, Louisiana, and following 1 application at Mansfield, Louisiana. However, the following year, 1 application of the same formulation at the same rate reduced S. invicta populations without affecting the non-target organisms listed above.

Reagan, et al. (1972) applied 6 pounds per acre of 4X mirex-bait in sugarcane fields. There were significant reductions in populations of S. invicta, Staphylinidae, Carabidae, and crickets.

Mirex 450 has been effectively used for the control of a number of species of attine ants: Atta sexdens rubropilosa Forel, A. laevigata (F. Smith)(Amante 1968a), A. capiquara Goncalves (Amante 1968b), A. texana (Buckley) (Echols 1966), and Acromyrmex octospinosus Reich (Cherrett and Sims 1966).

Crowell (1963) reported control of the western harvester ant, Pogonomyrmex occidentalis (Cresson) using 2X mirex bait at 3 pounds per acre in a plot in which there were 23 nests per acre. Good control was obtained with 5 pounds per acre where there were 37 nests per acre. Lavigne (1966) reported that although 1X and 2X mirex-bait at several low rates gave 100 percent control of P. occidentalis within 6 months, a population of the same species in central Wyoming did not accept the bait. It was found that a peanut meal-based bait was accepted by this population, and 100 percent control was achieved using this modified formulation. Mirex bait at 0.7 pounds AI per acre was reported by Baker (1963) to control Solenopsis geminata (F.). Ostmark (1974) reported that mirex-bait destroyed colonies of Pheidole species, while merely weakening nearby colonies of Solenopsis geminata.

Mirex-bait was developed for control of imported fire ants in the early 1960's (Lofgren, et al. 1961a, 1961b, 1962, 1964). The effectiveness of the product in controlling S. invicta was particularly well-demonstrated in a test in which the ant species was nearly eradicated from large land areas after 3 applications of 4X mirex-bait (Banks, et al. 1973). Levy, et al. (1974) recently reported that mirex-bait was superior to any other product yet tested for control of imported fire ants.

Table 1. Mirex-bait formulations for control of ant species.*

Type	Carrier	Attractant	Mirex
Mirex 450	91.05 % citrus pulp	8.5 % soybean oil	0.45 %
Mirex 4X	85 % corncob grits	14.7 % soybean oil	0.30 %
Mirex 2X	- - - - - - - - -	- - - - - - - - -	0.15 %
Mirex 1X	- - - - - - - - -	- - - - - - - - -	0.10 %

*Data from Alley (1973) and Echols (1966).

METHODS AND MATERIALS

Description of Study Areas

This study was conducted in 3 areas: the St. Gabriel Experiment Station operated by Louisiana State University; a large pasture under private ownership adjacent to the experiment station; and Ben Hur Farm, which is also operated by the University.

St. Gabriel and Ben Hur Farms are about 11 and 4 miles, respectively, south of the Louisiana State University campus at Baton Rouge. Both localities are on flat alluvial soil adjacent to the Mississippi River levee. Although the pastures are drained by systems of ditches and canals, prolonged rains result in brief partial flooding. For a few weeks in the spring of 1973, much of the pasture areas were under water. The soil is soggy in wet weather and may become brick-hard in dry periods. It is perennially pocked by cattle hoof prints.

Most of the work was done in improved pastures consisting predominantly of common Bermuda grass, *Cynodon dactylon* (L.) Persoon. Two large portions of the St. Gabriel area were poorly maintained pastures with a mixture of grasses and weeds common to this region, such as cocklebur, *Xanthium strumarium* L., *Sida rhombifolia* L., *Polygonum* spp., *et cetera*. The latter areas are referred to in this report as "weedy pastures."

The areas in acres and hectares of the pastures at St. Gabriel were determined with a planimeter from aerial photographs purchased from the Soil Conservation Service, U.S. Department of Agriculture. The areas of the Ben Hur pastures were determined from a map made by Emilio Icaza, Research Assistant, Department of Animal Science, Louisiana State University. Maps of the study areas are shown in Figures 1-5.

The cattle in the pastures were crossbreeds of different ages. Individual cattle were of different mixtures of Angus, Hereford, Jersey, Holstein, Zebu, and Charolais breeds. Usually a herd consisted of about 50 cows with or without calves, and 1 bull. The herd in the weedy pasture was usually somewhat larger than this.

Normal farm operations, including insecticidal treatment of cattle for protection against pests, were carried out during the experiments. It was therefore necessary to keep informed of farm operations and maintain flexibility in implementing the experiments.

Solenopsis invicta had been established in the experimental areas for about 15 years, according to local residents. Ben Hur Farm had been treated with heptachlor about 10 years prior to the present study. A survey of _S. invicta_ nests in pastures of the St. Gabriel Experiment Station about a month after the commencement of the experiment revealed that there were 23 to 62 active nests per hectare in areas not treated with mirex-bait.

General Description of the Experiments.

Two similar experiments were conducted, the first in the summer of 1972 and the second in the summer of 1973. These will be referred to as Experiments 1 and 2, respectively. Mirex-bait was applied at the beginning of both experiments to portions of the pastures and comparable areas were left untreated. During about 4 months following treatment, arthropod populations were sampled in treated and untreated plots.

The major difference between the 2 experiments was that in

Experiment 1 a block of 535 acres on the St. Gabriel Experiment Station was treated and samples taken in this treated area and in an untreated area of the same size (Fig 1). In Experiment 2, 6 separate 50-acre pastures were treated and 6 similar untreated pastures were designated as check plots. The pastures used in Experiment 2 were on the St. Gabriel Experiment Station, private land adjacent to the latter and on the Ben Hur Farm. (See map, Fig. 3).

Sampling Methods

Three major subunits of the pasture arthropod community in which S. invicta was believed to play a principal role were (a) the ground-inhabiting (epigeal) arthropod community, (b) the arthropod community associated with the herb layer, and (c) the arthropod community of cattle dung pats. These communities were sampled by means of pitfall traps, sweep net samples, and sampling of manure pats, respectively. In addition, nests inhabited by colonies of S. invicta (active nests), and unoccupied nests or those containing dead ant colonies (inactive nests) were sampled in Experiment 1. Ants were sampled with baits in Experiment 2. A general practice was to alternate between treatments in taking samples, so as to reduce bias. Care was taken that wind conditions, shading of manure pats by foliage, and any other environmental factors did not bias samples.

Pitfall traps. The pitfall traps were slightly tapered glass pint jars 9.5 cm. high, with mouth diameters of 2.4 cm. These were set into the soil so as to project about 1 cm. above the ground surface and soil was packed around the lips of the jars so as to slope to the ground surface. The latter procedure was followed so as to reduce the chances of the traps being filled with run-off rain water. Galvanized metal sheeting, 18 X 18 cm., provided shelter for the traps. These were supported over the traps by 12.5 cm.-long nails (20 penney) driven through each corner and into the soil, so that the cover rested about 3 cm. from the ground. Each jar contained 70 percent alcohol to a depth of about 3 cm. Varsol was poured over the alcohol solution to form a layer of about 3 cm. to reduce evaporation.

The traps were continuously operated in fixed localities in the field. During nearly every sampling period, 1 or more samples were lost to the experiment due to flooding by run-off, farming operations, or disturbance by the cattle. These lost trap collections were treated as missing data in the statistical analysis.

Traps were not placed on or immediately next to ant nests, because the latter were considered extraneous to the habitat of epigeal arthropods. If ants built a nest adjacent to a pitfall trap between collecting dates, the sample was discarded and the trap site relocated a few meters away.

About every 2 weeks, the jars that had been exposed in the field were collected and replaced with clean jars with fresh preservative. In the laboratory, specimens were transferred directly to labeled vials containing 70 percent alcohol.

In Experiment 1, pitfall trap sites were referred to by 3-digit code numbers. The first digit signified the treatment. A first digit of 1 signified that the trap site was located in an untreated pasture. A first digit of 2 signified that the trap site was in a mirex-treated pasture. The second 2 digits were the numbered trap sites. Thus, numbers 101, 102, 103...116 referred to trap sites 1 through 16 in the untreated pastures. Numbers 201, 202, 203...216 referred to trap sites 1 through

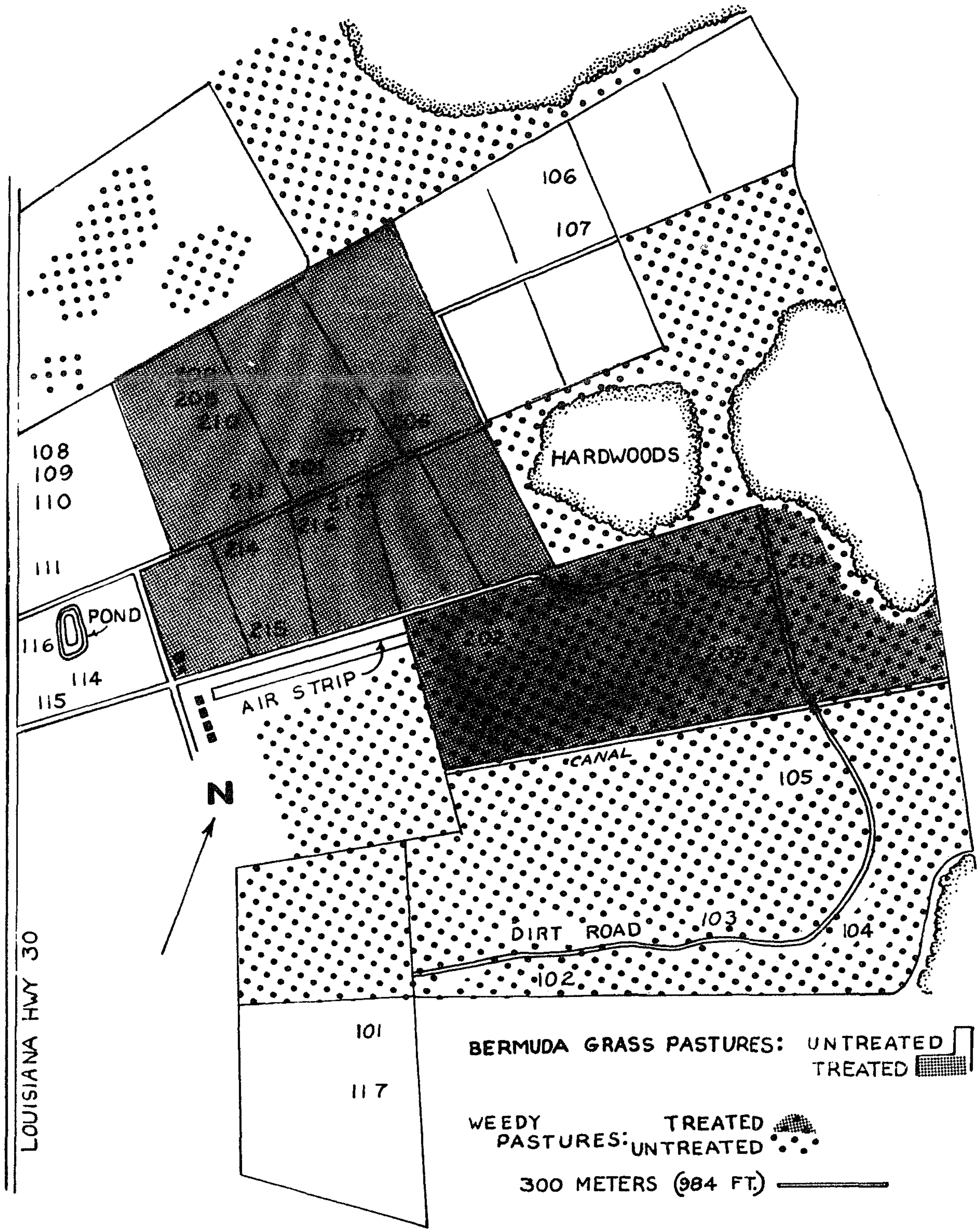


Figure 1. Map of St. Gabriel Experiment Station area, showing distribution of Bermuda grass and weedy pastures, hardwood stands, mirex-treated and untreated areas, and locations of pitfall traps in Experiment 1.

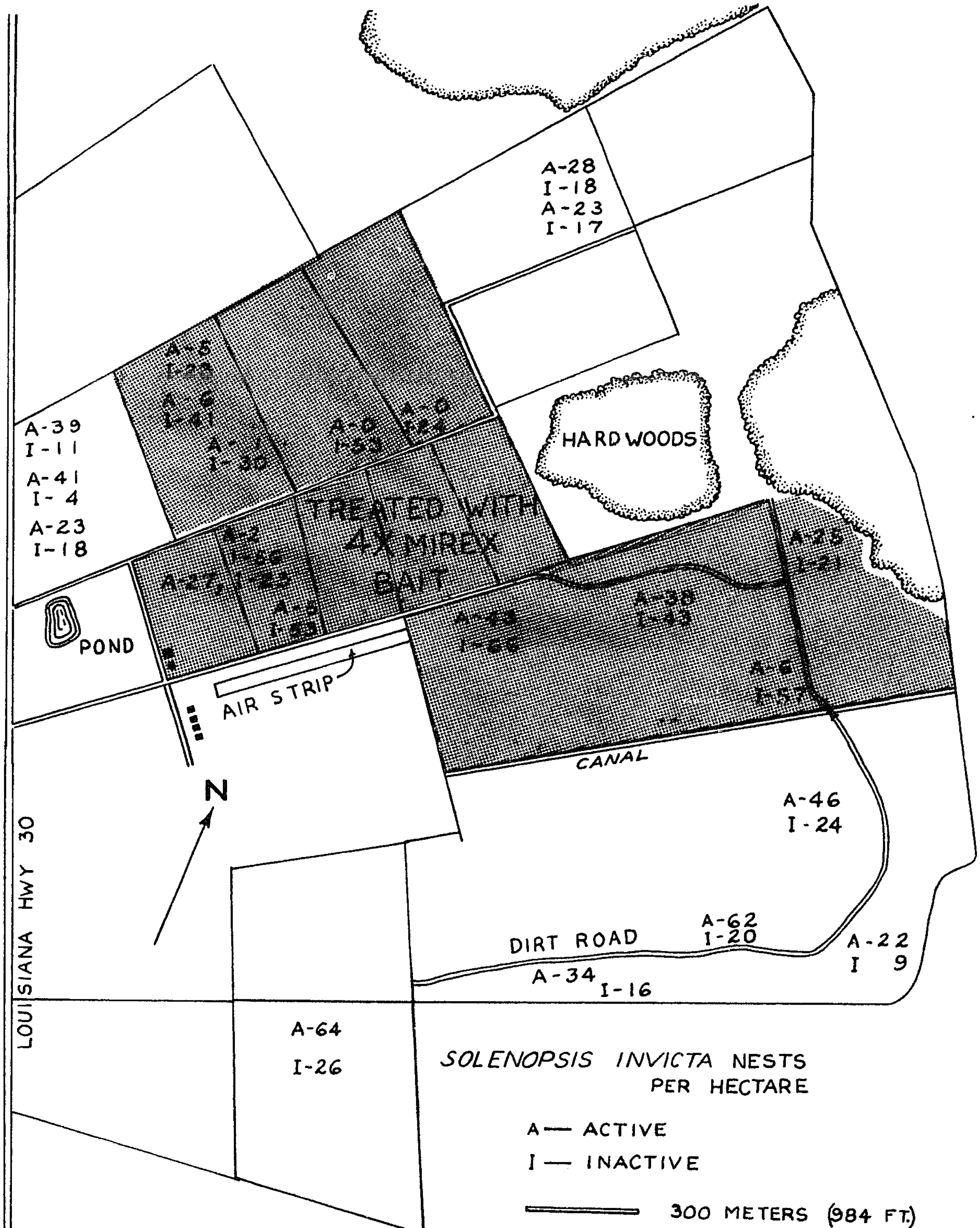


Figure 2. Map of St. Gabriel Experiment Station area, showing active (A) and inactive (I) Solenopsis invicta nests per hectare in various locations 20 days after the mirex-bait application in Experiment 1.

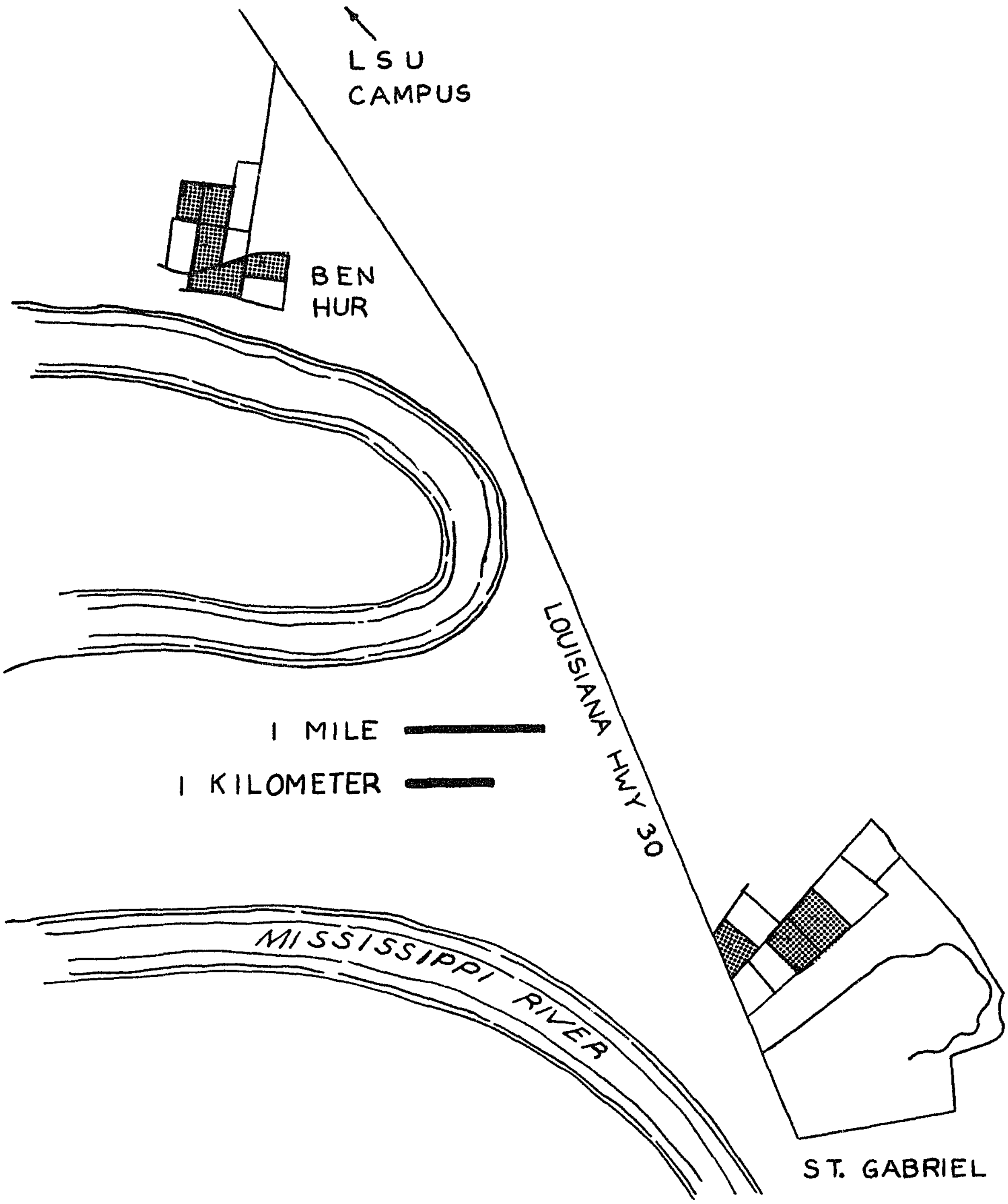


Figure 3. Map of area south of Louisiana State University campus, showing locations of study areas of Experiment 2.

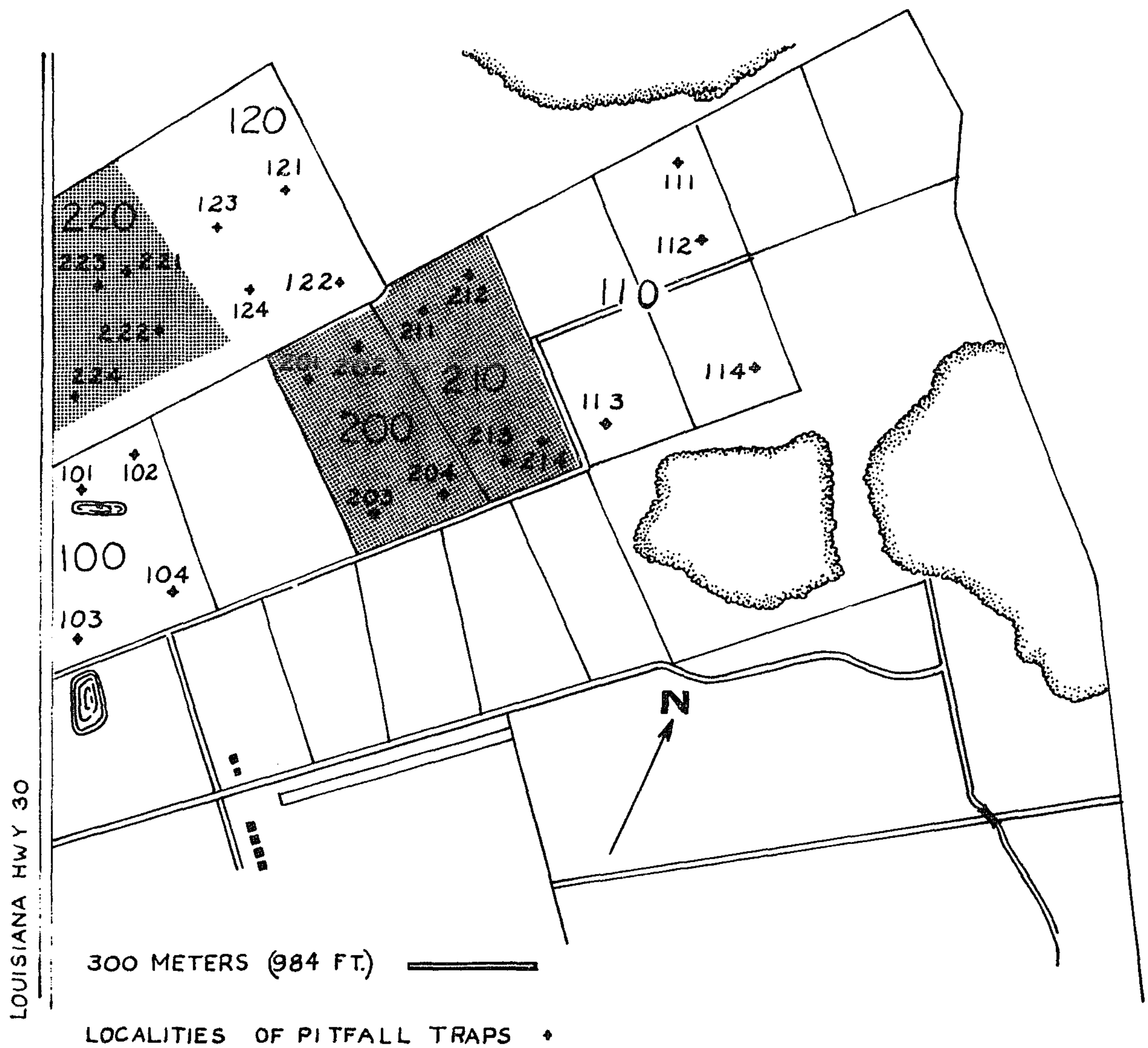


Figure 4. Map of St. Gabriel Experiment Station area, showing mirex-treated (shaded) and untreated (unshaded) areas, study pastures (large numbers) and locations of pitfall traps (small numbers), Experiment 2.

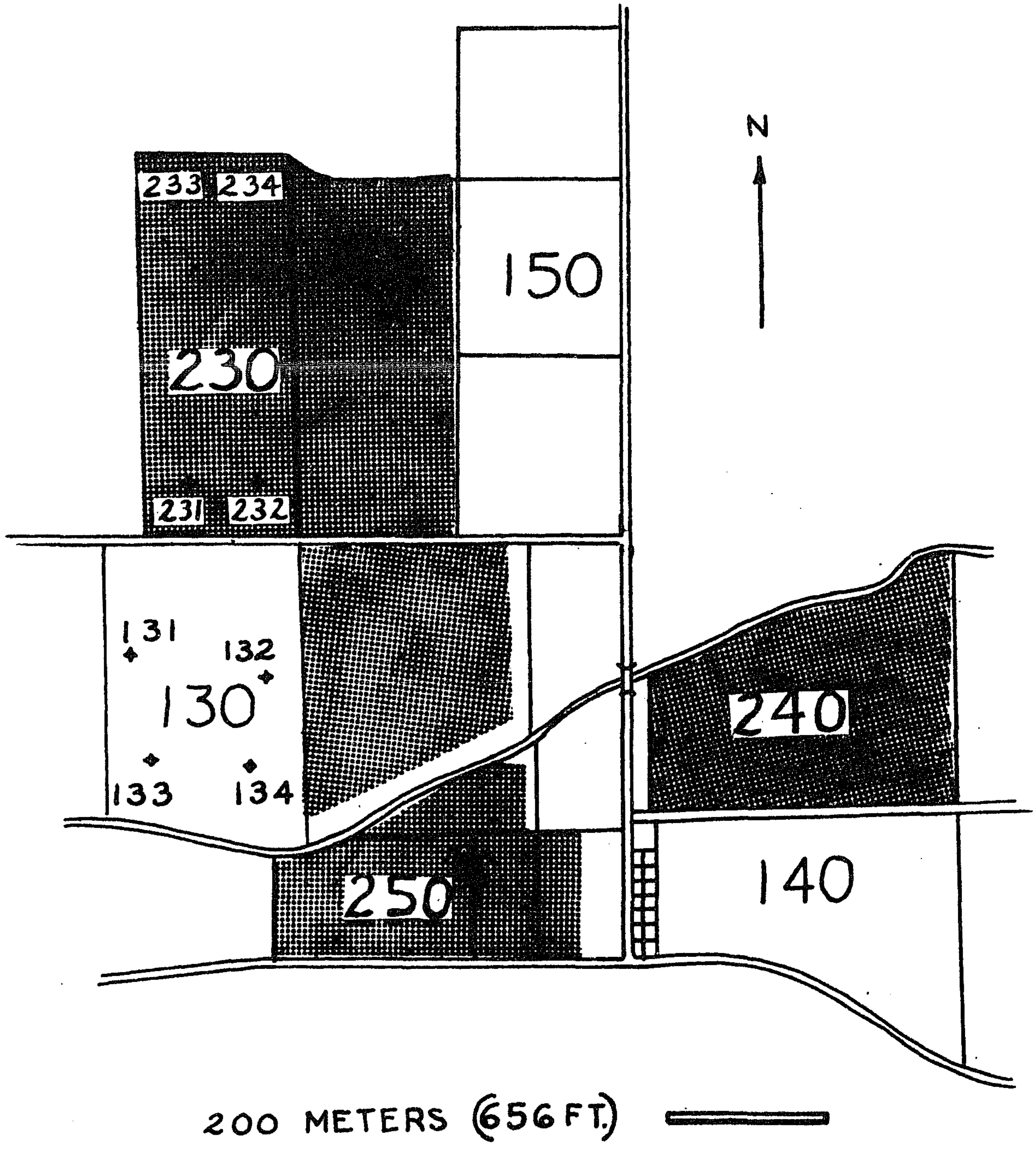


Figure 5. Map of Ben Hur Farm, showing mirex-treated (shaded) and untreated (unshaded) areas, study pastures (large numbers) and locations of pitfall traps (small numbers) Experiment 2.

16 in the mirex-treated pastures. Two pitfall traps were located at each numbered site (Fig. 1).

In Experiment 2, pastures and pitfall trap sites were referred to by 3-digit code numbers. The first digit referred to the treatment. The second digit was the pasture number. The third digit referred to the trap site. Thus, 111...114 referred to trap sites of pasture 110, which was untreated. Numbers 211...214 referred to pitfall trap sites of pasture 210, which was treated with mirex-bait (Figs. 4 and 5).

Sweep net collections. Each sweep net sample consisted of 120 sweeps with a canvas sweep net 22.5 cm. in diameter along a transect about 100 meters long. One sweep was taken with each step. The net was swung so as to penetrate the herb layer nearly to the soil surface. Each transect was located in a different place in the pastures in order to distribute the samples. Sweep net sampling was done alternately in treated and untreated pastures and paired by time of day. After taking a sweeping sample, the contents of the canvas net were shaken into a plastic bag, which was sealed and labeled. The samples were taken to the laboratory within 2 hours and frozen.

Sampling of cattle dung. Dung samples were observed when dropped from cattle. A manure pat was selected as a sample if it appeared to be normal physically. The date, time of day that the pat was dropped, general appearance of the cow (especially size and probable breed combination), and the locality were noted on a paper tag. The tag was attached beneath a metal disk of about 5 cm. in diameter. The disk was nailed into the ground over the tag on the west side of the dung pat. These disks were lid caps of jars used for pitfall traps. They protected the tags, were never disturbed by cattle, and were conspicuous and easily relocated. By placing them on the west sides of pats, sample pats were always immediately to the east of disks and therefore were not confused with other pats that had been deposited in close proximity to the samples.

The objective was to obtain paired samples. Observations were made and pats selected alternately between treated and untreated areas. Thus, a pair consisted of a manure pat from a mirex-treated area and 1 from a comparable untreated area. Samples of a pair were collected usually within about an hour of each other from cattle of similar breed combination and size, that had fed on the same type of forage. The development of immature horn flies, Haematobia irritans (L.), in dung is influenced by the time of day (Kunz, et al. 1970) and the diet of cattle (Morgan and Graham 1966). Weather conditions, exposure, shading, and any other local factors that might have influenced the microenvironments of the dung pats were considered when pairing.

After a period of 2 to 7 days of exposure in the field, the samples of each pair were collected within an hour of each other. The time periods for exposure of dung samples in the field were chosen because of the successional nature of dung fauna. During about the first week after deposition by cattle, the insects that inhabit dung are those that are restricted to dung breeding, or have a strong preference for it. These dung-breeding insects include the immature stages of horn flies, adults of which are parasitic on cattle. Immature horn flies develop in the dung to the adult stage in about 9 days in summer, based on data published by McLintock and Depner (1954) and by Bruce (1964). This first stage in the decomposition of dung, lasting about a week, is referred to by Mohr (1943) as the first microseral stage. Thereafter, dung begins to lose its intrinsic character and becomes like most other decaying plant matter. At this later microseral stage it serves primarily as a habitat for general scavengers (Mohr 1943).

Each sample manure pat was lifted from the ground with a spatula and placed in a plastic bag, which was then sealed, labeled, and taken to the laboratory and stored in a freezer.

At later dates, the frozen manure pats were thawed and fragmented in water. The resulting liquified mixture was washed through a series of sieves. The first, second, and third sieves were of 1/8th inch hardware cloth, standard window screening, and number 50 fine plastic mesh.

This procedure resulted in clean plant particles and insect specimens sorted into 3 size classes. This material was sorted through to extract insect specimens, which were placed in labeled vials containing 70 % alcohol solution, or K.A.A.D. (Peterson 1949) if the sample contained larval specimens.

Nest counts. In Experiment 1, an evaluation of the effects of the mirex application on *S. invicta* populations was made by counting active and inactive nests per unit area. These data on *S. invicta* populations were supplementary to pitfall trap data. Areas of 1-hectare each were measured off using a steel metric tape. In each 1-hectare acre, a complete survey of active and inactive nests was made by striking nests with a hammer. Nests were designated as active if apparently normal worker ants were visible, and inactive if ants could not be seen. If they were obviously morbid from the insecticidal treatment, the nest was considered inactive, but few cases of this were observed. During the afternoon, when temperatures were high, it was sometimes necessary to strike the nests several times before the ants would respond.

Bait stations. In Experiment 2, bait stations were used to sample ant populations to supplement the data on ants from pitfall trap collections. Bait cards 8 X 8 cm. were made out of cardboard soaked in soybean oil. A hundred of these cards could be stacked together in a plastic pail and carried in the field. They were placed flat on the ground so that the attractive edges and surfaces presented to patrolling ants were maximized.

Unshaded bait cards attracted ants in the morning or when there was heavy cloud cover. When sunshine was intense, ants were attracted to shaded, but not to unshaded baits. Peanut oil was found to be a better attractant than the soybean oil. The phagostimulant may be lost from highly refined soybean oil (Vinson, et al. 1967).

Identification of specimens. Once sampling had begun, taxa were selected for inclusion in the study. In general, the taxa selected were those considered to be potentially important in the arthropod community of pastures. It was a matter of individual judgement whether or not a taxon was of potential importance in the community. The relative frequency of taxa, their known or supposed trophic relationships, and the sizes of individuals was considered in making these judgements. A list of taxa identified from specimens is shown in Table 2.

Most specimens included in the study were determined to species. A number of pooled taxa (_i.e._, supraspecific categories) were included. The pooled taxa were those involving special problems in collecting or identification.

In identifying a species, a tentative identification was usually made by reference to the literature. A series of specimens from different samples was then sent to a specialist for examination. The result of this procedure was a reference collection pertaining to the study.

Determining frequencies of taxa in samples. Identifications were learned by means of the reference collection. Identifications and frequencies of taxa in samples were determined in the laboratory in the following manner: A series of parallel lines about 0.5 cm. apart was etched in the bottom of a flat, rectangular plastic dish by means of a needle. Colored wax was rubbed into the etched lines to make them more conspicuous. Using the etched lines as guides, the dish was moved through the field of a dissecting microscope and the specimens of selected taxa identified and counted. Counting was facilitated by means of two 9-unit laboratory counters.*

*Clay-Adams, Inc., New York, N.Y.

Table 2. List of taxa identified from specimens collected in pastures at St. Gabriel and Ben Hur Farm, Louisiana, Summer, 1972, 1973.

Taxon	Common name
CHILOPODA	Centipedes
DIPLOPODA	Millipedes
ARANEAE	Spiders
Lycosidae	Wolf spiders
Lycosa carolinensis Walkenaer	
Lycosa rabida Walkenaer	
Lycosa riparia Hentz	
Lycosa helluo Walkenaer	
Schizocosa avida (Walkenaer)	
Pardosa delicatula Gertsch and Wallace	
Pardosa milvina Hentz	
Pirata allapahae Gertsch	
Pirata sylvanus Chamberlin and Ivie	
Pirata alachuus Gertsch and Wallace	
Pirata seminola Gertsch and Wallace	
Pirata suwaneus Gertsch	
Clubionidae	Sac spiders
Trachelus deceptus (Banks)	
Erigonidae	
Eperigone tridentata Emerton	
Gnaphosidae	Mouse spiders
Zelotes laccus (Barrows) ?	
Thomisidae	Crab spiders
Misumenops sp.	

Table 2 (continued).

Taxon	Common name
ARANEAE (continued)	
Oxyopidae	Lynx spiders
Oxyopes sp.	
Salticidae	Jumping spiders
Pellenes sp.	
Araneidae	Orb-weavers
Neoscona sp.	
Acanthepeira sp.	
Singa sp.	
COLLEMBOLA	
Orchesella sp.	
Tomocerus sp.	
ORTHOPTERA	
Tettigoniidae	Long-horned grasshoppers
Conocephalus fasciatus fasciatus (DeGeer)	
Gryllidae	Crickets
Gryllus spp.	
Acrididae	Short-horned grasshoppers
Orphulella palidna palidna (Burmeister)	
DERMAPTERA	Earwigs
Euborellia annulipes (Lucas)	Ringlegged earwig
Labidura riparia (Pallas)	Striped earwig
Labia rotundata Scudder*	

* First U.S. record; previously known only from Mexico.

Table 2 (continued).

Taxon	Common name
HEMIPTERA	
Miridae	Plant bugs
Trigonotylus pulcher Reuter	
Lygaeidae	
Blissus insularis Barber	Chinch bug
Orthaea longulus (Dallas)	
Ligyrocoris sp.	
Pentatomidae	Stink bugs
Oebalus pugnax (F.)	Rice stink bug
Podisus maculiventris (Say)	Spined soldier bug
Euschistus servus servus (Say)	Brown stink bug
Euschistus ictericus (L.)	
HOMOPTERA	
Cicadellidae	
Carneocephala flavipes (Riley)	Yellowheaded leafhopper
Exitanus exitiosa (Uhler)	
Graminella nigrifrons (Forbes)	Blackfaced leafhopper
Draeculacephala spp.	
Chlorotettix viridis Van Duzee	
Membracidae	
Spissistilus festinus (Say)	Three-cornered alfalfa hopper
Cercopidae	
Prosapia bicincta (Say)	
Fulgoroidea	

Table 2 (continued).

Taxon	Common name
COLEOPTERA	
Carabidae	Ground beetles
Calosoma sayi DeJean	
Stenomorphus sp.	
Pterostichus chalcites Say	
Harpalus pennsylvanicus DeGeer	
Progaleritina lecontei DeJean	
Anisodactylus dulcicollis LaFerte	
Cratacanthus dubius Beauvois	
Cicindellidae	Tiger beetles
Megacephala virginica Latreille	
Staphylinidae	Rove beetles
Philonthus sp.	
Oxytelus sp.	
Histeridae	Hister beetles
Phelister haemorrous Marseul	
Anthicidae	Ant-like flower beetles
Vacusus vicinus (LaFerte)	
Acanthinus scitulus (LeConte)	
Rhizophagidae	Root-eating beetles
Monotoma picipes Herbst	
Cucujidae	Flat bark beetles
Ahasverus rectus (LeConte)	

Table 2 (continued).

Taxon	Common name
COLEOPTERA (continued)	
Coccinellidae	Lady beetles
Scymnus loewii Mulsant	
Coleomegilla maculata (DeGeer)	
Hyperaspis connectens (Thunberg)	
Cyclodena sanguinea (L.)	Spotless lady beetle
Hippodamia convergens Guérin-Méneville	Convergent lady beetle
Chrysomelidae	Leaf beetles
Diabrotica balteata LeConte	Banded cucumber beetle
Diabrotica undecimpunctata howardi Barber	Spotted cucumber beetle
Chaetocnema minuta Melsheimer	Flea-beetles
Longitarsus sp.	" "
Scarabaeidae	
Phyllophaga sp.	
Euphoria sepulchralis (F.)	
Euetheola rugiceps LeConte	Sugarcane beetle
Aphodius lividus (Olivier)	
Aphodius haemorroidalis (L.)	
Myrmecaphodius excavaticollis (Blanchard)	
Ataenius figurator Harold	
Ataenius spretulus (Haldeman)	
Ataenius picinis Harold	
Ataenius platensis (Blanchard)	
Ataenius apicalis Hinton	
Ataenius intiger Harold	

Table 2 (continued).

Taxon	Common name
COLEOPTERA (continued).	
Scolytidae	Bark, wood-boring, ambrosia beetles
Xyleborinus saxeseni (Ratzeburg)	
Xyleborus affinis Eichhoff	
Xyleborus lecontei (Hopkins)	
Curculionidae	Weevils
Sphenophorus cariosus (Olivier)	
Sphenophorus venatus subsp. *vestitus* Chittenden	
DIPTERA	
Pipunculidae	Big-headed flies
Tomosvaryella subvirescens (Loew)	
Tomosvaryella coquilletti (Kertesz)	
Tomosvaryella sp.	
Syrphidae	Flower flies
Mesograpta marginata (Say)	
Sepsidae	Black scavenger flies
Sepsis brunnipes (Melander and Souler)	
Palaeosepsis insularis (Williston)	
Dolichopodidae	Long-legged flies
Asyndetus sp.	
Chrysotus sp.	
Ephydridae	Shore flies
Ceropsilopa mellipes (Coquillett)	
Leptopsilopa atrimana (Loew)	

Table 2 (continued).

Taxon	Common name
DIPTERA (continued).	
Chloropidae	
Hippelates dissidens (Tucker)	
Hippelates particeps (Becker)	
Oscinella carbonaria (Loew)	
Olcella trigramma (Loew)	
Monochaetoscinella nigricornis (Loew)	
Muscidae	
Haematobia irritans (L.)	Horn fly
Orthellia caesarion (Meigen)	
Sarcophagidae	Flesh flies
Ravinia lherminieri (Robineau-Desvoidy)	
Ravinia derelicta (Walker)	
Calliphoridae	Blow flies
Cochliomyia macellaria (F.)	Secondary screwworm
LEPIDOPTERA	
Spodoptera frugiperda (J.E. Smith)	Fall armyworm
HYMENOPTERA	
Ichneumonidae	
Diadegma pattoni (Ashmead)	
Braconidae	
Chelonus texanus Cresson	
Rogas sp.	
Apanteles sp.	

Table 2 (continued).

Taxon	Common name
HYMENOPTERA (continued).	
Chalcidae	
Spilochalcis hirtifemora (Ashmead)	
Eulophidae	
Euplectrus sp.	
Bethylidae	
Dissomphalus sp	
Dryinidae	
Pseudogonatopus iowensis Fenton	
Neogonatopus mimoides Perkins	
Neogonatopus brunnescens Perkins	
Neogonatopus sp.	
Gonatopus sp.	
Rhopalosomatidae	
Olixon banksii Brues	
Mutillidae	Velvet-ants
Formicidae	Ants
Pseudomyrminae	
Pseudomyrmex pallidus (F. Smith)	
Ponerinae	
Hypoponera opaciceps (Mayr)	

Table 2 (continued).

Taxon	Common name
Formicidae (continued).	
Myrmicinae	
Crematogaster ashmeadi Mayr	
Crematogaster clara Mayr	
Pheidole floridana Emery	
Leptothorax schaumi Roger	
Monomorium minimum (Buckley)	Little black ant
Cyphomyrmex rimosus (Spinola)	
Solenopsis molesta (Say)	Thief ant
Solenopsis invicta Buren	Red imported fire ant
Formicinae	
Nylanderia melanderi arenivaga (Wheeler)	
Nylanderia parvula (Mayr)	
Camponotus pennsylvanicus (DeGeer)	Carpenter ant
Camponotus nearcticus Emery	
Camponotus sayi Emery	
Camponotus (*Colobopsis*) sp.	

Procedures of Experiment 1 (1972)

An area of 216.6 hectares (535 acres) was treated with an aerial application of 4X mirex-bait at a rate of 1.42 kilograms (4.26 grams AI) per hectare. This was equivalent to 1.25 pounds (0.00375 pounds AI) per acre. The application was made with an AgCat aircraft applying 60-foot swaths, on the morning of June 6. The weather was clear and winds were 0 to 14.8 kilometers per hour (0 to 8 miles per hour) from the south. Flagmen guided the airplane. Treated and untreated areas are shown in Figures 1 and 2.

Twenty-seven days prior to the insecticide application, 68 pitfall traps were installed in the pastures in the pattern shown in Figure 1. In each numbered site (101-117 and 201-217), 1 square hectare was measured off and pitfall traps installed 50 meters from each of 2 corners of the square.

This pattern was devised in an attempt to establish paired comparisons, because of the patchy nature of the pasture habitat at the beginning of the experiment. Close pairing seemed necessary because, as shown by Greenslade (1964), catches of epigeal arthropods vary with the difficulty of movement due to different plant densities and other features of the vegetation and ground surface. However, throughout the season the patterns of vegetation and land use changed so that the pairing effect was lost. Therefore, the pitfall trap samples were treated as random samples.

Pitfall trap samples were collected 19 and 10 days prior to the mirex-bait application. Thereafter, samples from the traps were collected every 12 to 14 days during the summer and every 14 to 18 days during September and October.

Between June 22 and June 25, i.e., beginning 16 days after the mirex-bait application, a survey of the active and inactive nests in in the 1-hectare areas was made.

Between July 13 and 19, i.e. beginning 38 days after the mirex-bait application, sweeping samples were taken in the treated and untreated pastures. Two to 6 paired samples were taken every 1 to 2 days during this period.

Between July 18 and August 31, i.e., beginning 42 days after the mirex-bait application samples of cattle dung pats were taken. Fourteen samples of dung pats were taken after 6 days of exposure. Fifteen samples were collected after 3 to 4 days of exposure.

Procedures of Experiment 2 (1973)

On May 29 and 30, and June 8, a total of 6 pastures of 20.3 hectares (50 acres) each were treated with 2X mirex-bait by means of a jeep-mounted applicator. The applicator was calibrated to put out 2.8 kilograms per hectare (2.5 pounds per acre). The rate of the active ingredients per acre was the same as in Experiment 1. By weighing the material before treatment, and any excess in the hopper after treatment, the actual rates applied to each pasture were calculated. These are shown in Table 3. The treated and untreated pastures are shown in Figures 3, 4, and 5.

Pitfall traps were installed 100 meters towards the center of the pasture from the 4 corners of pastures 100, 200, 110, 210, 120, and 220 at St. Gabriel, and 130 and 230 at Ben Hur Farm. Pitfall traps were put in pastures at St. Gabriel 32 days before the mirex-bait application, and collected 22 days before and 3 days after the application. In the

Table 3. Treatment of pastures with 2X mirex-bait with jeep-mounted applicator, showing pastures treated, rates of application, and dates of treatments.

Pasture Code Number	Rate of Application (pounds of bait/acre)	Date of Treatment
200	2.22	May 30
210	2.79	May 30
220	3.28	May 29
230	2.60	May 29
240	2.04	May 30
250	2.46	June 8

pastures at Ben Hur Farm, pitfall traps were installed 16 days before the mirex-bait application. Collections of samples were made 5 days before and 10 days after the application. During May and June, pitfall trap collection dates were 14 to 17 days apart. Specimens were in poor condition after that length of time in the field. Thereafter, collections were usually made at weekly intervals. Collection dates at St. Gabriel were different from those at Ben Hur Farm until July 15, after which the collecting dates for all pastures were the same.

About 1-$\frac{1}{2}$ months after the mirex-bait application, ant populations were sampled by placing baits on the ground. In each of 6 treated pastures and their corresponding untreated check pastures baits were placed 10 meters apart in a transect across the pasture. Twenty to 25 baits were placed in each pasture and observed after about an hour. The number of Solenopsis invicta workers at each bait was recorded as 0-10, 11-50, or more than 50.

Between September 19 and 26, i.e., about 3-$\frac{1}{2}$ months after the mirex-bait application, baits were again placed in 3 treated and 3 untreated pastures.

Beginning July 26 in the Ben Hur area and August 1 in the St. Gabriel area, i.e., about 2 months after the mirex-bait application, sweep net samples were taken every 2 to 6 days until the end of August. On each sampling day, 2 to 7 pairs of samples were taken. Seventeen paired samples were taken from the St. Gabriel area and 22 pairs from the Ben Hur area.

Although it would have been desireable to sample manure pats in all of the study pastures more or less simultaneously throughout the season, farm practices extraneous to the experiment did not permit this.

The sampling procedure was therefore opportunistic.

During June 1973, high numbers of adult horn flies were observed on cattle in pastures 210 and 110. These pastures were contiguous and horn fly populations appeared to be equally distributed over the cattle of these 2 pastures. Both herds had about 50 cattle of mixed breeds and ages. Neither herd had been treated for control of horn flies. Pitfall trap data and ground inspection of the area showed that S. invicta populations had been greatly reduced in pasture 210, but were high in 110.

Attention was devoted to sampling dung in these 2 pastures from June 21 until July 5. Dung pats were collected after 95.5 to 149.5 hours in the field.

Beginning on July 6, the cattle in pastures 110 and 210 were used in a study of insecticides extraneous to the present study. Thereafter, sampling of dung pats shifted to other paired pastures. Pastures 120 and 220 were sampled from June 29 until August 31. There was no fence between these 2 pasture areas and a single herd of cattle had ready access to both mirex-treated and untreated pastures. All cattle of this herd had access to a Zipcide* cattle dust bag, which contained 1 % coumaphor as an active ingredient. The dust bag was located in pasture 220 on June 1 by the owner of the cattle and was not removed during the sampling period. The populations of adult horn flies appeared uniformly low on cattle during the experiment.

Occasionally, the herd was found to be distributed between the treated and untreated areas, but more often, cattle were congregated in either the mirex-treated or in the untreated area. In the latter situation, after a dung sample was observed to be defecated in 1 of the treatment areas, the

* Franklin Laboratories, Denver, Colorado.

cattle were moved to the oppcsite treatment area, in order to obtain paired dung samples.

Sample dates were between June 29 and August 31 and were at intervals of 1 to 32 days, but most of the samples were taken in August at intervals of 1 to 6 days. The irregularity of sampling dates resulted from the difficulty of manipulating the herd so as to get acceptable paired samples. The most frequent reasons for rejecting dung pats as samples were differences between paired samples in shading of the pats, differences in sizes of the pats, and differences in sizes and colors of cattle.

Eleven pairs of samples were taken. Dung samples in pastures 120 and 220 were collected after 142.6 to 178.0 hours in the field.

Sampling of dung pats in pastures 150 and 250 was conducted August 15 to September 15. Most of these samples were taken at intervals of 2 to 5 days during the last 2 weeks of August. Bait sampling on September 19 showed that Solenopsis invicta populations were high in the treated pasture (Table 8). Thus, the samples from pastures 150 and 250 did not provide valid comparisons of areas inhabited by Solenopsis invicta and ant-free areas, and were not included in the experiment.

Statistical Analysis of Data

Pitfall trap sample data were analyzed in 2 ways. (1) Analysis of variance was computed for 33 arthropod categories for each collecting period. (2) Data from samples collected over a 65- to 70-day period following the mirex-bait treatment in each experiment were analyzed by the same procedure as (1). The rationale for combining data in this way was that the longer the pitfall traps are left in place, the higher the numbers of specimens caught in them. The 65- to 70-day periods were thus considered as single sampling periods.

Analysis of variance was computed for selected arthropod categories in sweep net samples. Sample data of selected insect categories in dung pat samples were analyzed by the paired t-test.

RESULTS AND DISCUSSION

Experiment 1, 1972

Pitfall traps. The mean numbers of specimens of selected arthropod categories collected in pitfall traps on each collecting date in Appendix Table 1, and graphed in Figures 6 through 18. Spiders and ants were represented in the samples by relatively high numbers of specimens, and thus were concluded to be the 2 arthropod groups of greatest ecological importance in the epigeal community. The taxa in samples from weedy pastures appeared to be essentially the same as those from Bermuda grass pastures.

Among the different categories of spiders, species of the *Pardosa delicatula*-*milvina* complex, which range in length from about 5 to 8 mm. were represented by relatively high numbers. Two other spider categories represented by high numbers of specimens were unidentified Lycosidae 4 to 8 mm. in length and unidentified spiders. Smaller spiders, *viz.*, *Trachelus deceptus* (Banks), *Pirata* spp., and unidentified Lycosidae under 4 mm. in length were less well represented. Their populations were probably more dense than their numbers indicated. Small animals tend to occur in disproportionately low numbers in relation to their densities because of relatively less mobility. Conversely, large animals occur in disproportionately higher numbers (Greenslade 1964).

There were approximately as many *S. invicta* workers as total Araneae in pitfall traps. *Nylanderia* spp. were the second most frequent ant species but were collected in far fewer numbers than *S. invicta*. Species of *Nylanderia* were not differentiated because of the difficult taxonomy of the genus.

An ambrosia beetle, Xyleborinus saxeseni (Ratzeburg), was relatively abundant in the samples. Early in the study it was assumed that these beetles were important members of the pasture community and efforts were made to locate their host plants. Through correspondence with Wood (1972) it was learned that the beetles were probably migrants from nearby hardwood forests. They evidently dispersed widely, and may have been attracted to the chemicals in the pitfall traps.

A small difference between treatment areas ($P<0.05$) in numbers of sugarcane beetles, Euetheola rugiceps (LeConte), occurred between May 26 and June 6 (Appendix Table 1 and Figure 12). Otherwise, there were no significant differences between treatment areas in numbers of 33 selected taxa prior to treatment. It was concluded that the arthropod communities of both treatment areas were similar.

Following the mirex-bait treatment on June 6, there was a reduction in the numbers of Solenopsis invicta in the treated pastures ($P<0.01$). On June 19, twelve days after the treatment, there was an average of 7.9 S. invicta workers per trap from the untreated areas and 1.9 per trap from the mirex-bait treated areas. Similar differences in numbers of S. invicta occurred between treated and untreated areas from June 19 through August 23. From August 23 until November 6 numbers of S. invicta did not differ significantly between treatment areas. Sampling was discontinued November 6 (Figure 18).

Numbers of sac spiders, Trachelus deceptus (Banks), were lower in mirex-treated areas than in untreated areas between June 6 and 19 ($P<0.05$) (Figure 6). Between July 1 and 13, numbers of unidentified Araneae were higher ($P<0.05$) in the mirex-treated than in the untreated

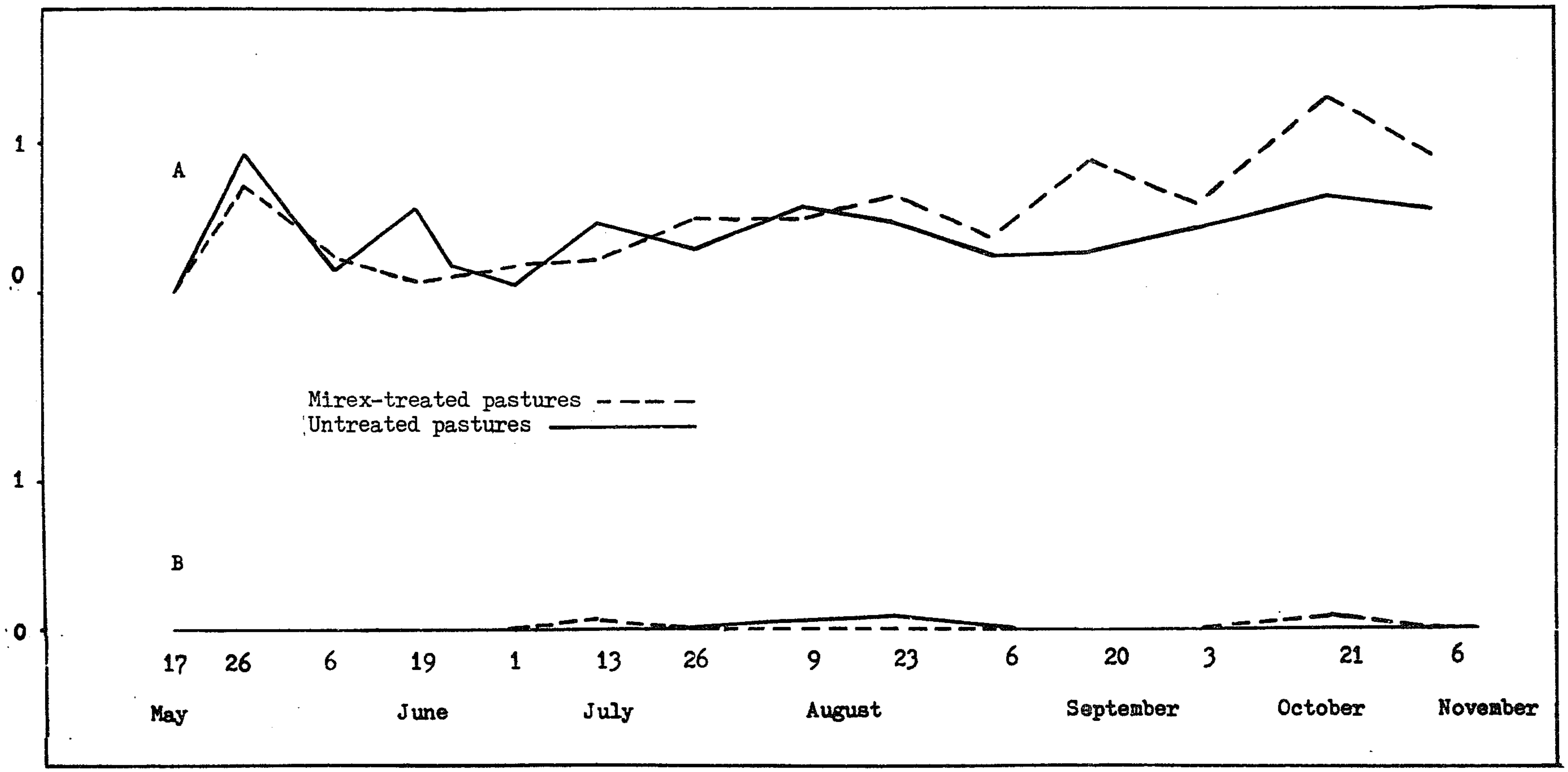
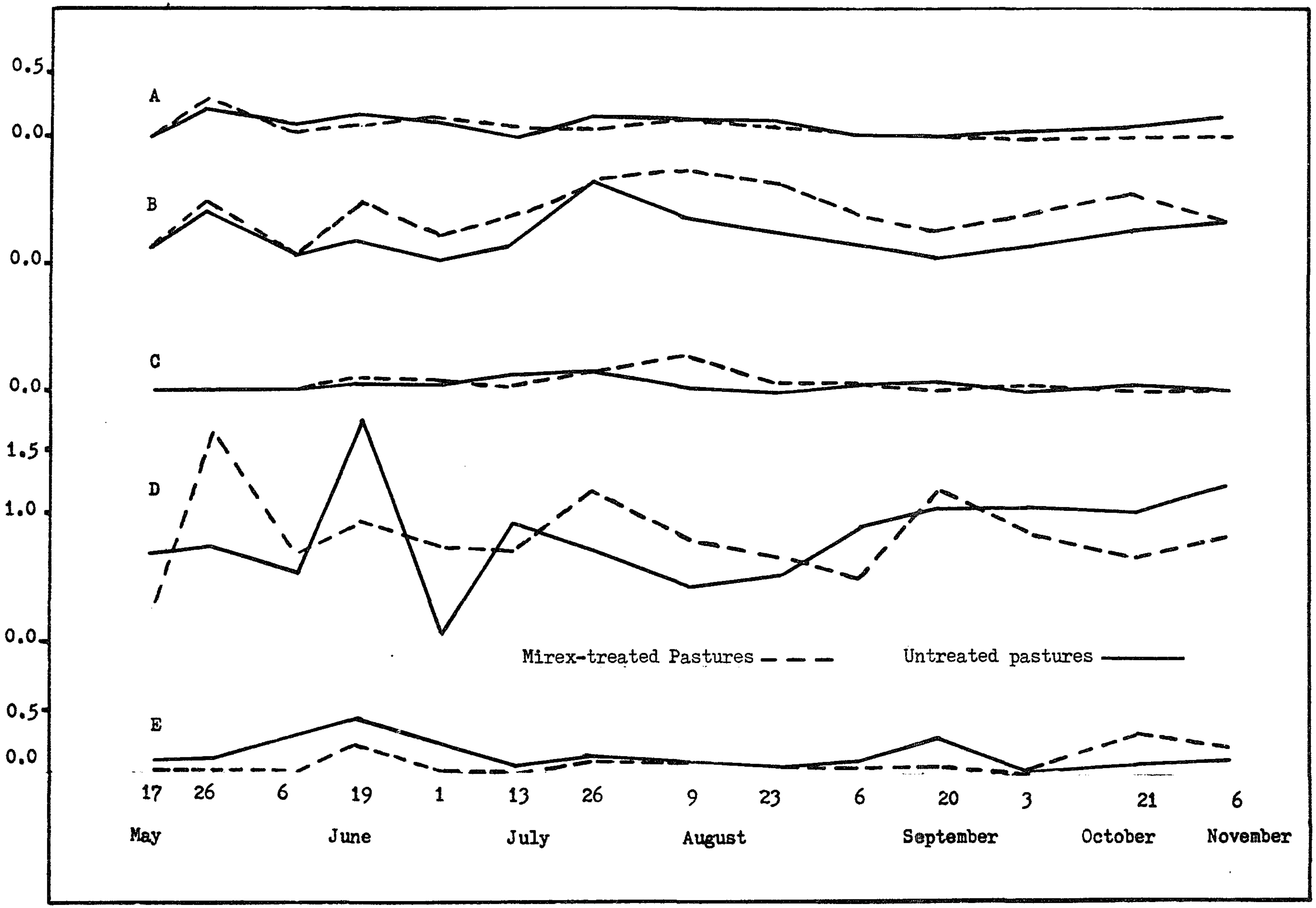


Figure 6. Average numbers of (A) sac spiders, Trachelus deceptus (Banks), and (B) wolf spiders, Lycosa carolinensis Walkenaer per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

Figure 7. Average numbers of wolf spiders: (A) *Lycosa rabida* Walkenaer, (B) Lycosa *riparia-helluo* complex, (C) *Schizocosa avida* (Walkenaer), (D) *Pardosa delicatula-milvina* complex, and (E) *Pirata* spp., in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.


0.5
A
0.0
B
0.0
C
0.0
1.5
D
1.0
0.0
Mirex-treated Pastures
Untreated pastures
0.5
E
0.0
17 26 6 19 1 13 26 9 23 6 20 3 21 6
May
June
July
August
September
October
November

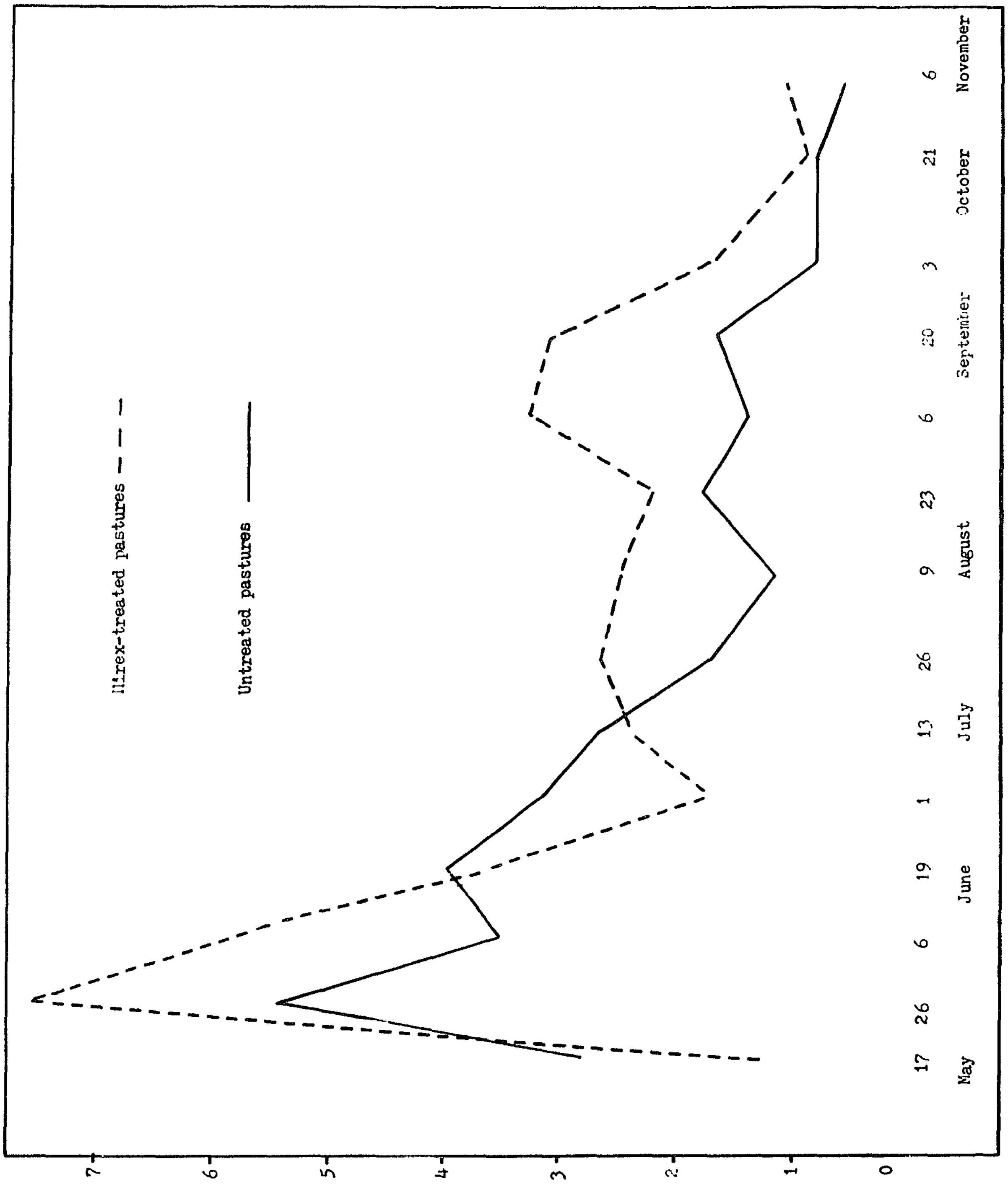


Figure 8. Average numbers of unidentified Lycosidae between 4 and 8 mm. long per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

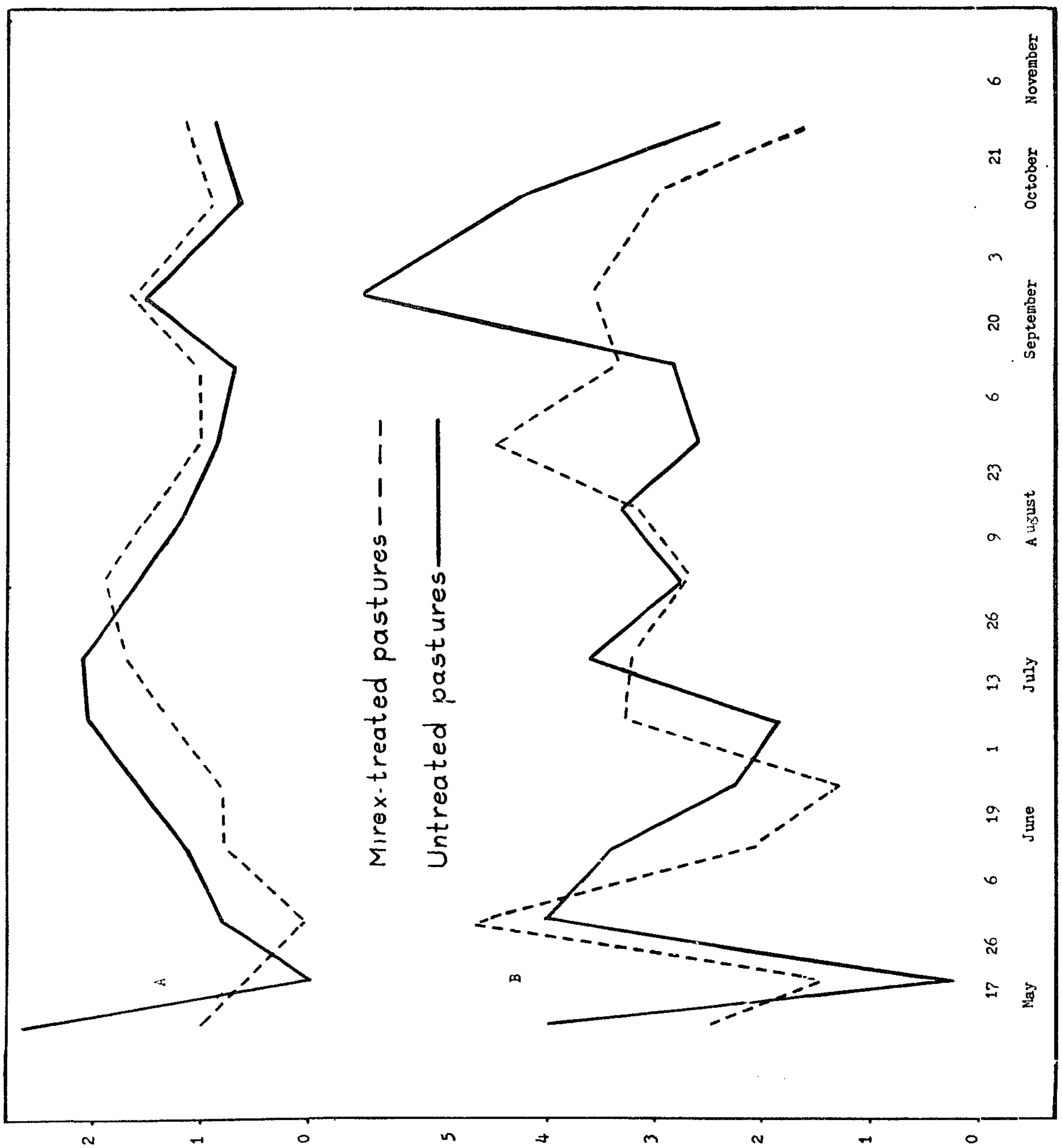


Figure 9. Average numbers of (A) unidentified Lycosidae under 4 mm. long and (B) unidentified Araneae per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

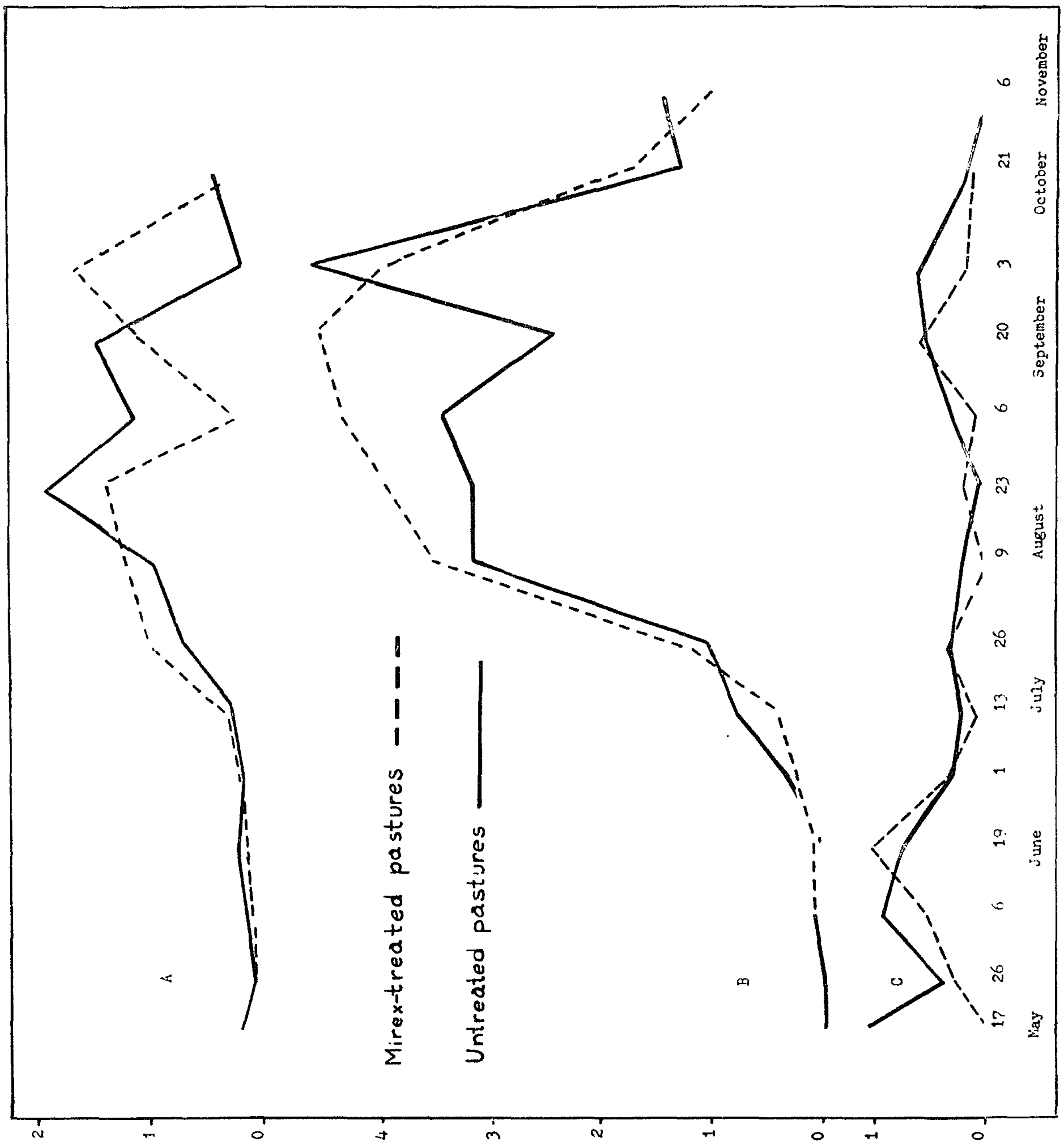
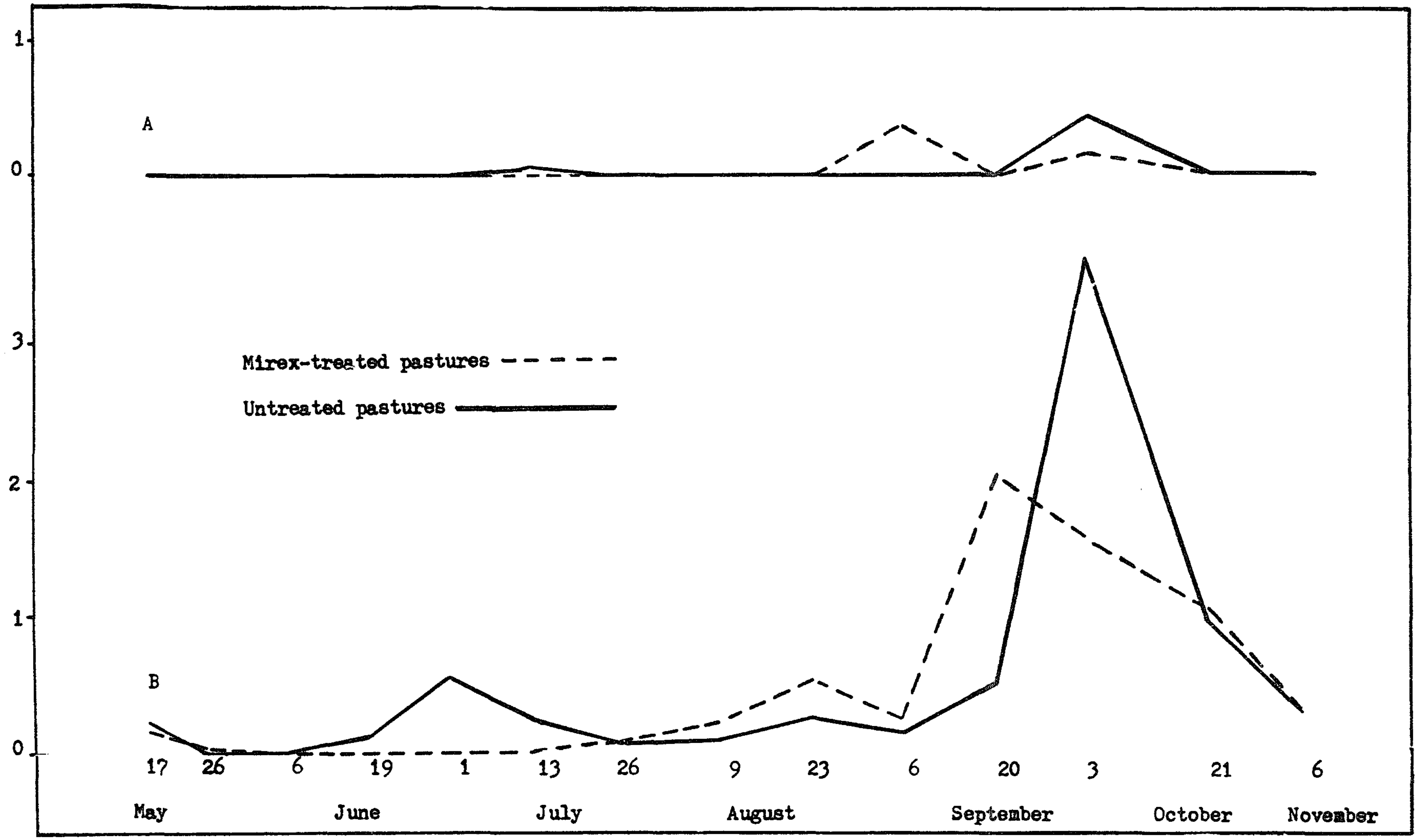


Figure 10. Average numbers of crickets: (A) Gryllus spp., (B) Gryllidae nymphs, and (C) unidentified Gryllidae adults per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

Figure 11. Average numbers of (A) striped earwigs, Labidura riparia (Pallas) and (B) ringlegged earwigs, Euborellia annulipes per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972



1
A
0
3
Mirex-treated pastures
Untreated pastures
2
1
B
0
17 26 6 19 1 13 26 9 23 6 20 3 21 6
May June July August September October November

Figure 12. Average numbers of (A) fall armyworms, Spodoptera frugiperda (J.E. Smith), (B) dung beetles, Aphodius lividus (Olivier), (C) all Aphodiinae, and (D) sugarcane beetles, Euthe ɔla rugiceps (LeConte) per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

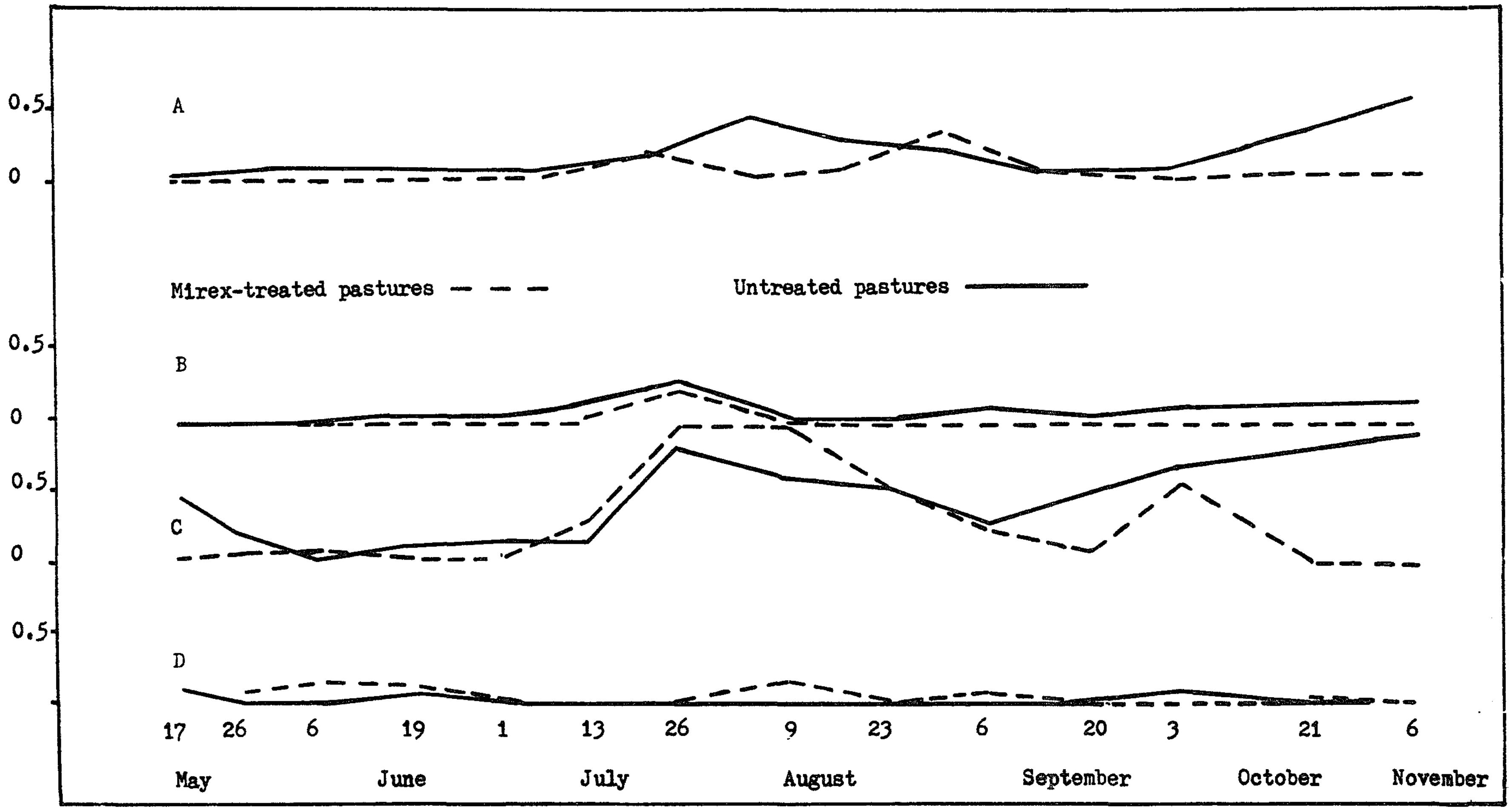
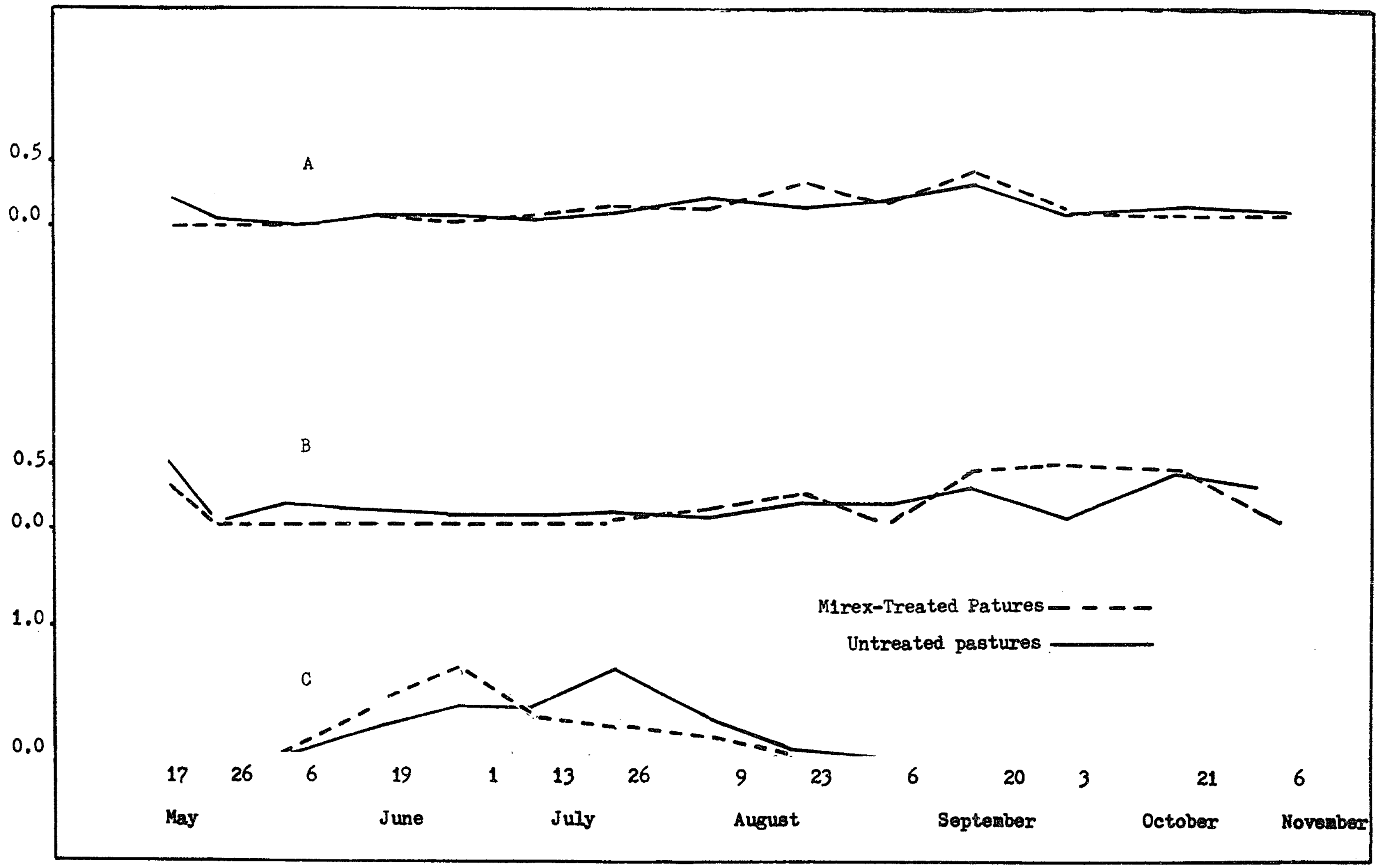

0.5
0
A
Mirex-treated pastures
Untreated pastures
0.5
B
0
0.5
C
0
0.5
D
17
26
6
19
1
13
26
9
23
6
20
3
21
6
May
June
July
August
September
October
November

Figure 13. Average numbers of (A) weevils, *Sphenophorus* spp., (B) ground beetles, Carabidae, and (C) tiger beetles, *Megacephala virginica* Latreille per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.


0.5
A
0.0
0.5
B
0.0
1.0
Mirex-Treated Patures
Untreated pastures
C
0.0
17
26
6
19
1
13
26
9
23
6
20
3
21
6
May
June
July
August
September
October
November

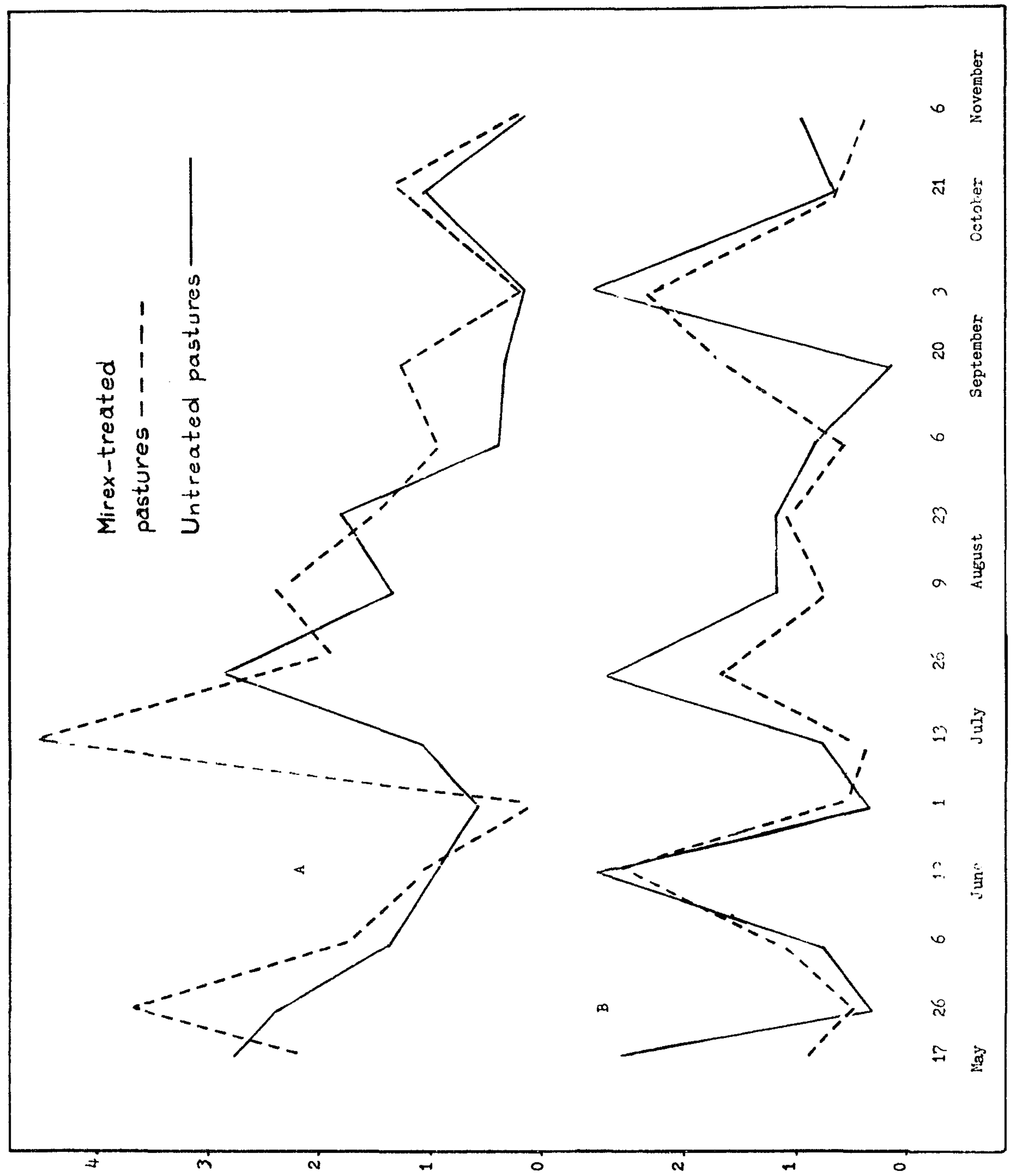


Figure 14. Average numbers of (A) ambrosia beetles, Xyleborinus saxeseni (Ratzeburg), and (B) rove beetles, Staphylinidae, per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

Figure 15. Average numbers of ant-like flower beetles, Vacusus vicinus (LaFerte) per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

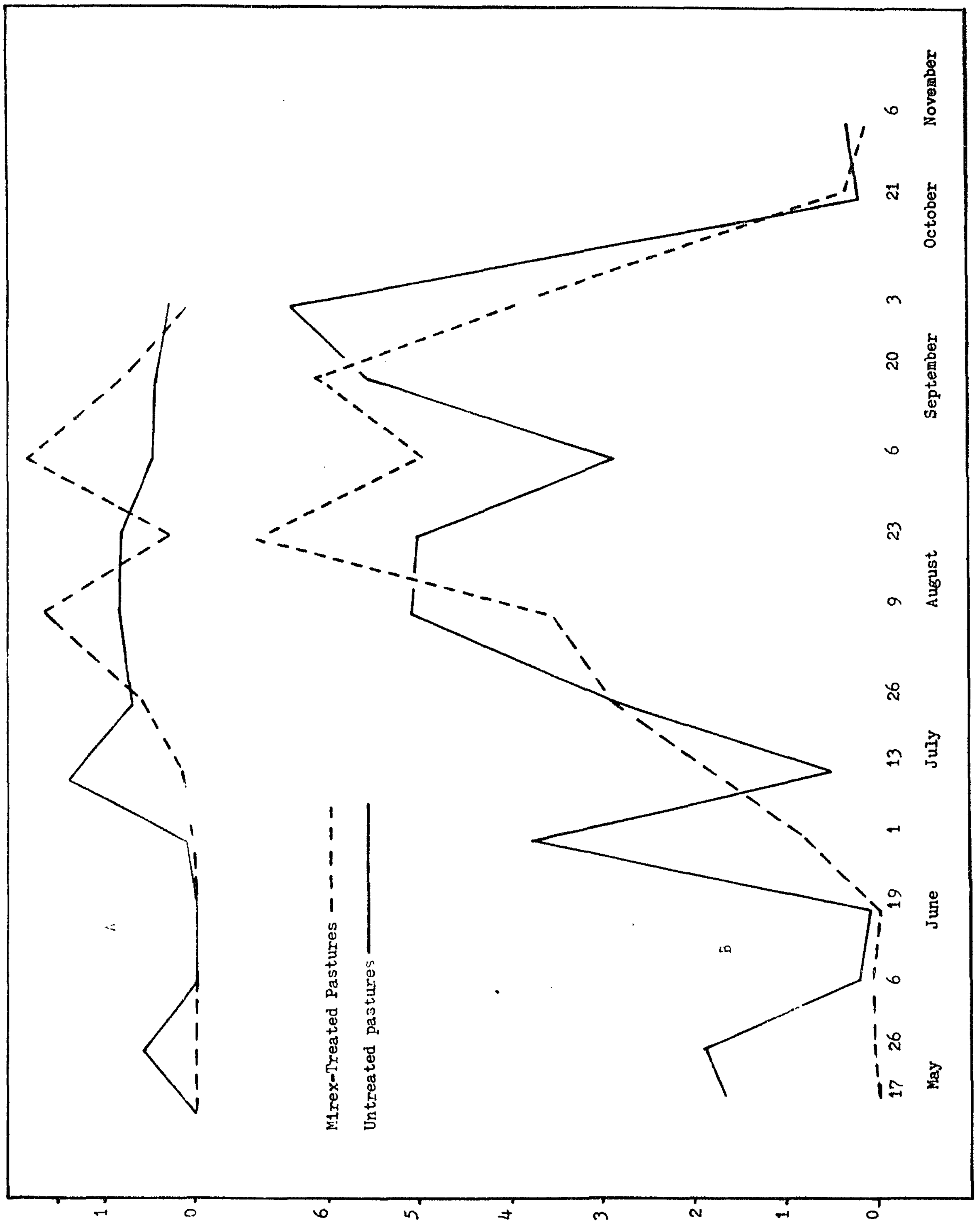
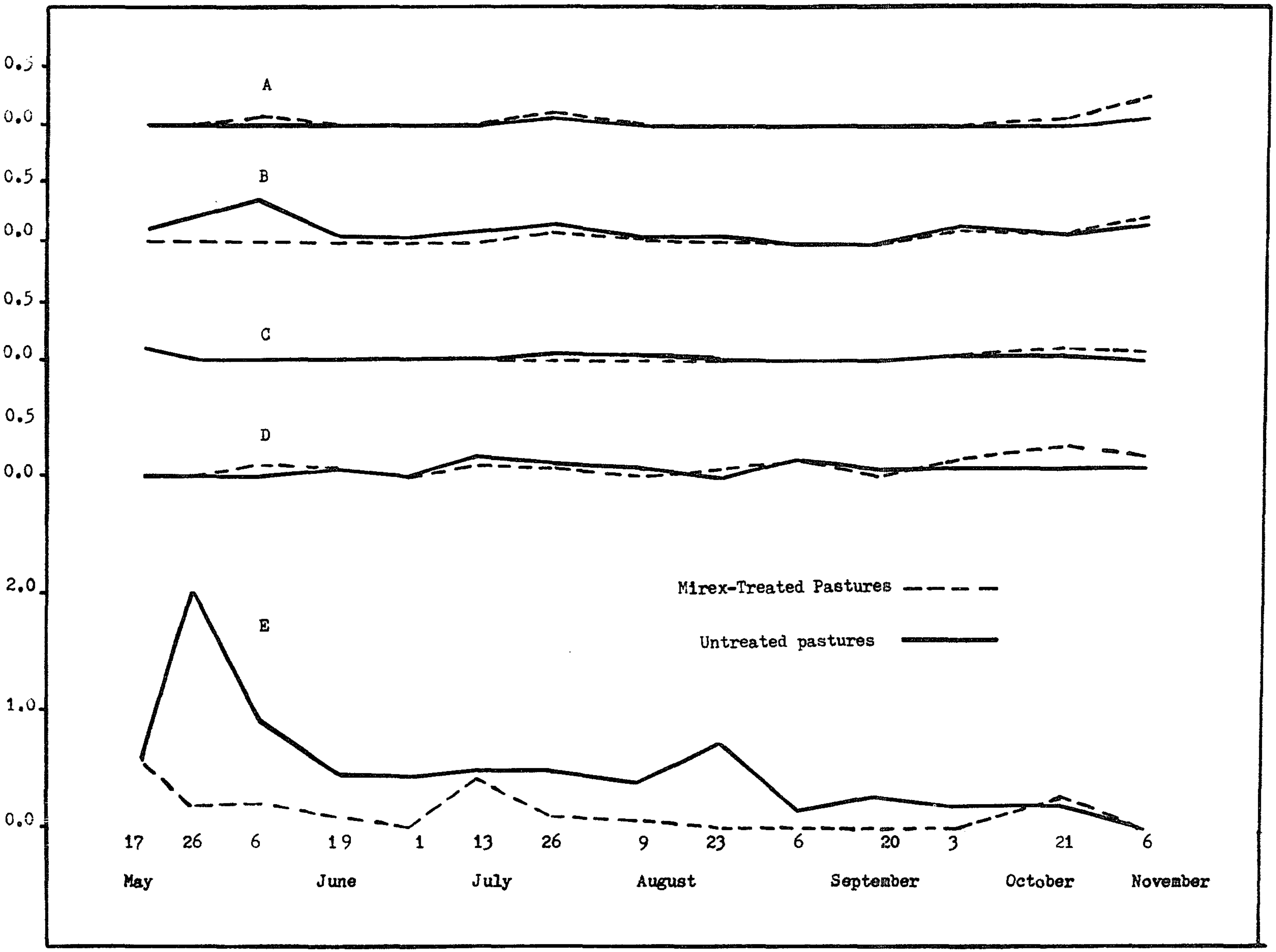


Figure 16. Average numbers of (A) root-eating beetles, Monotoma picipes Herbst, and (B) flat bark beetles, Ahasverus rectus (LeConte) per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

Figure 17. Average numbers of (A) millipedes, Diplopoda, (B) centipedes, Chilopoda, (C) fungus ants, *Cyphomyrmex rimosus* (Spinola) (D) ponerine ants, *Hypoponera opaciceps* (Mayr), and (E) formicine ants, *Nylanderia* spp. per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.


0.5
0.0
A
0.5
0.0
B
0.5
0.0
C
0.5
0.0
D
2.0
1.0
0.0
E
Mirex-Treated Pastures
Untreated pastures
17
26
6
19
1
13
26
9
23
6
20
3
21
6
May
June
July
August
September
October
November

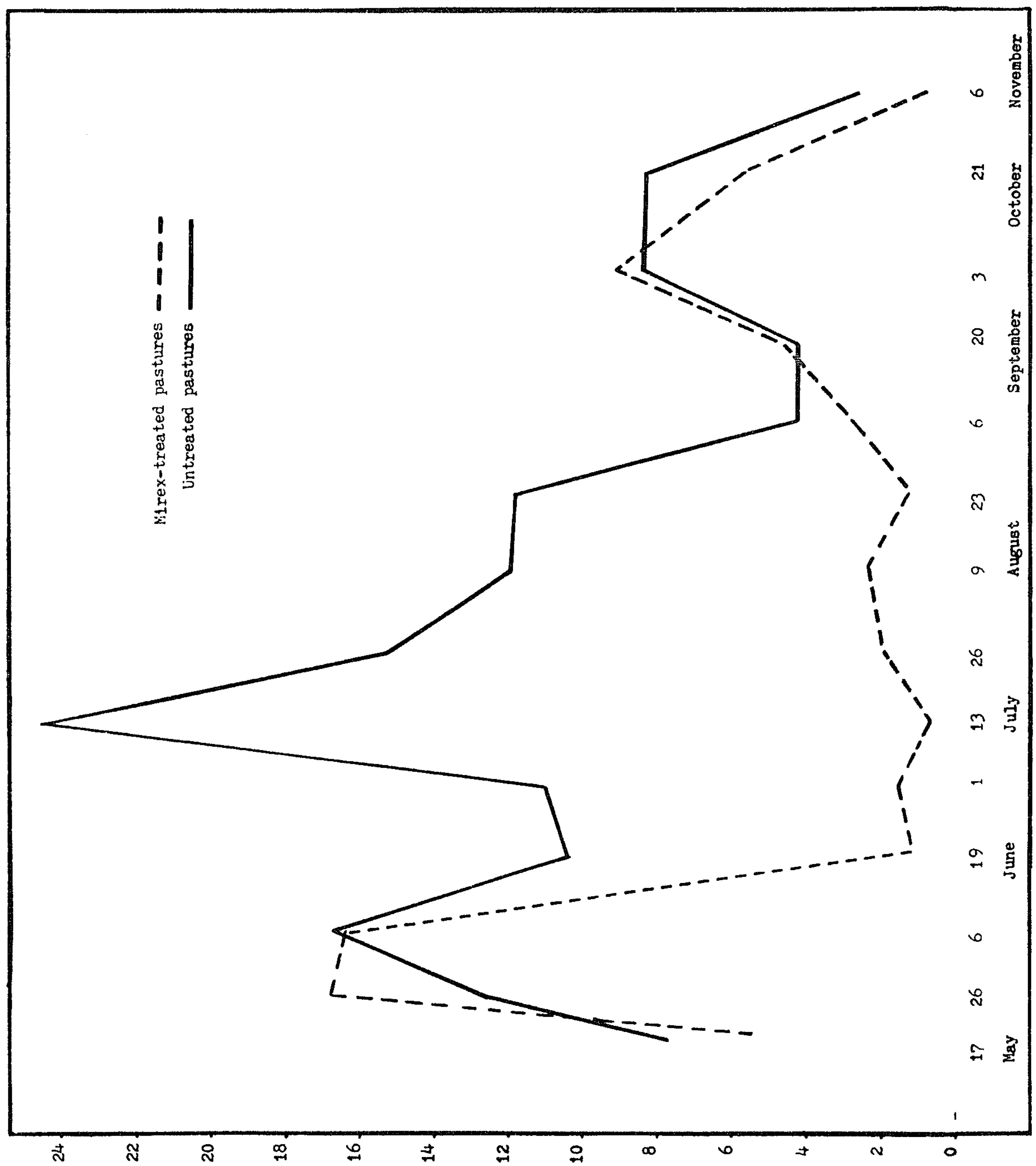


Figure 18. Average numbers of red imported fire ants, Solenopsis invicta Buren, per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel Experiment Station, Louisiana, 1972.

areas (Figure 9). Between August 23 and October 3, unidentified Lycosidae 4 to 8 mm. in length occurred in higher numbers ($P<0.05$) in samples from mirex-treated areas than from untreated areas (Figure 8). These short-range changes were interpreted as responses to factors that differed between treatment areas. The population ecology of spiders may be complicated. Studies by Breymeyer (1967) suggested that in addition to being important predators of insects, epigeal spider species preyed upon one another to a sufficient degree to constitute a significant factor in controlling densities.

Populations of ant-like flower beetles, Vacusus vicinus (LaFerte), were significantly higher in the mirex-treated areas than in untreated areas ($P<0.05$) between August 9 and August 23 and between September 6 and September 20 (Figure 15). No information was found concerning their ecological role in pastures. One specimen was reported as collected in old cattle dung (Wolcott, 1936). Many Anthicidae are associated with decaying plant matter (Imms, 1964).

The numbers of Carabidae were significantly higher in the mirex-treated pastures than in the untreated pastures ($P<0.05$) between August 23 and September 6 and between September 20 and October 3 (Figure 13). While species of Carabidae collected during the summer were small ground beetles of about 10 mm. in length, those collected in samples in late September and October were mostly larger beetles of about 24 mm. in length, including Calosoma sayi DeJean and Progaleritina lecontei DeJean. The higher numbers of these beetles in treated pastures in late summer and autumn may indicate that S. invicta preyed upon their eggs or immature stages earlier in the summer.

There were significantly fewer ambrosia beetles, Xyleborinus saxeseni (Ratzeburg), in the untreated than in the mirex-treated areas ($P<0.05$) between August 23 and September 6 (Figure 14). There were fewer formicine ants, Nylanderia spp., in the treated than in the untreated areas ($P<0.05$) between September 6 and 20 (Figure 17). There were fewer dung beetles, Aphodius lividus (Olivier) in the treated than in the untreated areas ($P<0.05$) between October 3 and 21 (Figure 12).

The results of analyzing combined data from June 19 to August 23 showed that numbers of wolf spiders of the Lycosa riparia-helluo complex (Figure 7) and Vacusus vicinus (Figure 15) were higher and numbers of Nylanderia spp. lower (Figure 17) in the mirex-treated areas than in the untreated areas ($P<0.05$).

It was concluded on the basis of pitfall trap sample data of Experiment 1 that the mirex-bait application greatly reduced S. invicta numbers in the treated area within 2 weeks following treatment. The treated area became repopulated by high numbers of S. invicta about 2 months after treatment. By analyzing the data by sampling periods, most of which were of 2 weeks duration, it was revealed that there were short-range differences between treatments in different components of the spider community and in certain species of beetles. The latter phenomena were interpreted as responses of populations to unknown temporary ecological factors or adjustments of populations to new conditions resulting from the treatment. Sampling data combined for a 70-day period following treatment revealed that there were more wolf spiders of the Lycosa riparia-helluo complex and Vacusus vicinus present and fewer S. invicta and Nylanderia spp. in the treated than in the untreated areas. The most pronounced effect of the mirex treatment on the epigeal arthropod community was the reduction of numbers of S. invicta.

Nest counts. Observations on active and inactive nests per hectare conducted about 20 days after the mirex-bait application in Experiment 1 revealed that there was an uneven reduction in active nests throughout the treated area (Figure 2). Eight of the 1-hectare areas sampled in the treated area had 6 or less active nests per hectare and 4 of the plots had over 25 active nests, indicating that after 20 days the treatment had not been uniformly effective. The average number of active nests per hectare was 13.2 in the treated area and 38.2 in the untreated area. Apparently, either the aerial application was highly uneven, or the effect of the treatment was delayed in some parts of the treated area.

Sweep net samples. Table 4 shows average numbers of selected taxa in 18 paired sweep net samples taken July 11 through 19 in mirex-treated and untreated Bermuda grass pastures at St. Gabriel Experiment Station.

There were higher numbers of Trigonotylus pulcher Reuter adults in the treated than in the untreated areas ($P<0.05$). This plant bug was the most frequent species in sweeping samples from Bermuda grass pastures. Numbers of flea-beetles, Longitarsus sp., were significantly lower in the mirex-treated than in the untreated areas ($P<0.05$).

Average numbers of selected taxa in 4 paired sweep net samples taken July 17 through 19 in weedy pastures are shown in Table 5. This limited number of samples was not treated statistically. Inspection of the data suggests that T. pulcher, as well as the first 3 species of leafhoppers listed in Tables 4 and 5 preferred Bermuda grass to the vegetation dominant in the weedy pastures.

Table 4. Average numbers of certain insect taxa per 120 sweeps in mirex-treated and untreated pastures, Experiment 1, St. Gabriel, Louisiana, 1972. 1)

Taxon	Untreated	Treated
Trigonotylus pulcher Reuter	237.7 *	352.2 *
Graminella nigrifrons (Forbes)	72.9	61.7
Carneocephala flavipes (Riley)	62.3	69.5
Exitanus exitiosa (Uhler)	47.9	50.9
Draeculacephala spp.	14.7	14.2
Chlorotettix viridis Van Duzee	12.4	8.1
Delphacodes propinqua (Fieber)	2.3	1.6
Spissistilus festinus (Say)	4.4	4.7
Chaetocnema minuta Melsheimer	36.3	41.4
Longitarsus sp.	17.3	3.1

1) Eighteen paired comparisons.

* Significant difference ($P < 0.05$).

Table 5. Average numbers of certain insect taxa per 120 sweeps in mirex-treated and untreated weedy pastures, Experiment 1, St. Gabriel, Louisiana, 1972. [1]

Taxon	Untreated	Treated
Trigonotylus pulcher		
Adults	3.0	11.0
Nymphs	0	0
Carneocephala flavipes	0.5	0.25
Exitanus exitiosa	1.5	10.75
Graminella nigrifrons	1.5	0.25
Draeculacephala spp.	7.75	26.75
Chlorotettix viridis	18.75	21.75
Prosapia bicincta	0	0.25
Delphacodes propinqua	0	0
Spissistilus festinus	0.25	3.6
Diabrotica balteata	0	0.5
Diabrotica undecimpunctata howardi	0.25	0.0
Scymnus loewii	3.75	5.5
Chaetocnema minuta	7.0	10.5
Longitarsus sp.	2.75	4.5

1) Four paired comparisons.

Table 6. Average numbers of selected insect taxa per 120 sweeps in mirex-treated and untreated Bermuda grass and weedy pastures Experiment 1, St. Gabriel, Louisiana, July 17-19 and August 21-18, 1972.[1)]

Taxon	Untreated	Treated
Trigonotylus pulcher		
Adults	172.9 *	270.4 *
Nymphs	15.5	40.2
Carneocephala flavipes	55.3	62.0
Exitanus exitiosa	53.6	45.1
Graminella nigrifrons	73.3	44.4
Draeculacephala spp.	12.1	15.0
Chlorotettix viridis	12.1	9.9
Prosapia bicincta	0.7	0.5
Delphacodes propinqua	2.8	1.5

[1)]Twenty-six paired comparisons.

* Significant difference ($P<0.05$)

Paired sweep net samples taken in untreated and mirex-treated Bermuda grass and weedy pastures at St. Gabriel on July 11-19, and on August 21,23, and 28 were combined. The mean numbers of specimens of selected taxa in samples from treated and untreated pastures are shown in Table 6. Numbers of T. pulcher were higher in mirex-treated than in untreated pastures ($P<0.05$).

The higher numbers of T. pulcher in mirex-treated pastures than in untreated pastures may have been due to the absence of predation by S. invicta. The lower numbers of Longitarsus sp. in the mirex-treated than in the untreated areas are not understood. Species of Longitarsus are phytophagous (Blatchley 1921; Horn 1889). Pasture weeds are likely to be their hosts.

Dung sampling. The average numbers of specimens of selected insect categories in paired dung pat samples from mirex-treated and untreated pastures are shown in Table 7. There were no significant differences between treatments in frequencies in any category in the dung pats that had been exposed 3 to 4 days in the field.

In the 5-day exposed dung pats, the average number of horn fly pupae was 8.4 in samples from the mirex-treated pastures compared to 3.8 in samples from untreated pastures ($P<0.05$). Conversely, there were fewer aphodine beetles in pats from mirex-treated than from untreated pastures ($P<0.05$).

The species of Aphodiinae collected in cattle dung in this study included Aphodius haemorrhoidalis (L.) and 4 species of Ataenius: A. platensis (Blanchard), A. spretulus (Haldeman), A. apicalis Hinton, and A. intiger Harold. Those collected in pitfall traps included

Myrmecaphodius excavaticollis (Blanchard), Aphodius lividus (Olivier), and 3 species of Ataenius: A. figurator Harold, A. spretulus (Haldeman), and A. picinis Harold. Of the species collected in pitfall traps, all but A. figurator and M. excavaticollis are known to occur in cattle dung (Woodruff 1974). Thus, there were at least 7 species of coprophagous Aphodiinae in the study pastures.

In attempting to learn whether the presence of greater numbers of aphodine beetles influenced the reduction of horn fly pupae in dung pats from untreated areas, the natural history of these beetles was considered. The coprophagous Aphodiinae develop within dung pats, rather than bury dung as do the Scarabaeinae (Halffter and Matthews 1966). The beetles enter the dung a day or so after it has been deposited by cattle and remain temporarily to feed and in some cases oviposit. Aphodine larvae develop in later successional stages of the dung after most Diptera immatures have completed their development and emerged as adults.

Under certain conditions, aphodine beetle adults may influence populations of Diptera in dung. Wolcott (1924, cited by McLintock and Depner 1954) reported that Aphodius lividus and Ataenius stercorator (F.) were so abundant in the dry season in Puerto Rico that survival of horn fly immatures was impaired. Lindquist (1933) was of the oppinion that the riddling of dung by these beetles probably hastened dessication, thus causing unfavorable conditions for development of horn fly immatures. Mohr (1943) concluded from observations of Aphodius distinctus Mueller that the beetles interfered with the development of dung-breeding Diptera by inadvertently breaking up egg clusters of the flies. In contrast, Poorbaugh, et al. (1971) stated that in California there appeared to be little competition for food and space in cattle droppings, and that predation was the most important natural factor regulating populations of flies that develop in dung.

Since in the present study the dung pats were observed when dropped and again when collected, their condition during the period in which Diptera develop them was well known. Although they were often riddled by beetles, they remained moist during the first 4 days. It is doubtful that activities such as those mentioned by Mohr (op. cit.) would have would have influenced horn fly populations.

The reasons for lower numbers of Aphodiinae in dung pats from the mirex-treated areas are not known. Three possibilities were considered. (1) Suppression of S. invicta may have released a natural enemy of 1 or more species of Aphodiinae from predation by the ant. Major governing factors of 1 species of Aphodius in Australia are interspecific competition between beetles, and mortality of beetles due to a species of fungus (Carne 1966). Governing factors of aphodines have apparently not been studied in North America. (2) One or more species of aphodine beetles may have fed on the mirex-bait. (3) Aphodines may have scavenged dead insects killed by mirex and thus accumulated amounts toxic to themselves. Dung feeding insects are often omnivorous scavengers and it is possible that beetles could have entered nests and fed on masses of ants killed by mirex. The third possibility seems most likely.

On 3 occasions during the study, S. invicta were observed carrying pupae or larvae of H. irritans from dung pats. S. invicta workers were often found in concentrations underneath dung pats that had been exposed for about 5 days or more in untreated pastures. It was common to get stung by the ants when sampling these pats, a fact which suggested that the ants were attempting to protect a favored food source.

Predation upon dung-inhabiting Diptera larvae by S. invicta was reported by Hays and Hays (1959). Predation on immature H. irritans by ants was reported by Bruce (1964) in Texas. Pogonomyrmex barbatus (F. Smith), P. occidentalis Cresson, Eciton coecium (Latreille), and Stigmatoma pallipes Halderman were the ant species observed. The range of S. invicta extends to a limited portion of Texas (Buren, et al. 1974) and perhaps for this reason the species was not observed by Bruce. Wheeler (1910, footnote, p. 512) cited evidence that predation by ants suppressed outbreaks of dung-breeding flies in the Philippine Islands. Laurence (1954) observed a species of Myrmica carrying fly maggots and adults from cattle dung in England. Wilton (1962-1964) observed ants preying upon fly larvae in dog excrement in Hawaii. Since he observed this only once in the course of collecting 130 samples, he concluded that ants were not important in controlling flies breeding in excrement. Legner (1965) reported that 3 species of ants, including S. geminata, appeared to be important predators of Musca domestica L. breeding in dung in stables in Puerto Rico.

In summary, evidence from the present study and published observations strongly suggest that S. invicta influenced the significant difference between treatments in numbers of horn fly pupae in dung pats.

Table 7. Average weights and dimensions of dung pats, and average numbers of specimens of selected insect categories per pat in samples from mirex-treated and untreated patures at St. Gabriel and Ben Hur Farm, Louisiana, Experiments 1 and 2 (1972 and 1973).

Pasture & Treatment	Avg. Weight of Dung Pats (gms.)	Avg. Dimensions of Dung Pats(Cm.)	*Haematobia irritans*	Sarcophagidae	Aphodiinae	Staphylinidae *Philonthus*	Staphylinidae Others	*Phelister haemorrous*
		(Dung pats exposed in field 3-4 days, Experiment 1)						
Untr.	1235.3	21.3 X 26.4	3.8	4.4	46.6	1.5	39.4	1.9
Mirex-Tr.	1467.8	22.4 X 26.4	5.5	8.4	22.3	3.6	62.9	2.4
		(Dung pats exposed in field 6 days, Experiment 1)						
Untr.	784.8	20.4 X 25.0	3.8 *	3.5	8.7 *	0	12.1	0.8
Mirex-Tr.	661.4	16.1 X 20.1	8.4 *	3.5	1.9 *	0.4	4.1	1.4
		(Dung pats exposed in field 4-7 days, Experiment 2)						
110 (Untr.)	642.0	22.8 X 24.8	7.4 *	7.2	26.3	3.2	0.7 *	3.1
210 (Mirex)	951.2	22.2 X 24.1	36.7 *	7.1	11.2	4.8	15.8 *	7.2
120 (Untr.)	1045.8	22.4 X 25.1	1.8	3.5	5.2	2.6	86.6	6.2
220 (Mirex)	977.4	18.6 X 28.0	3.8	1.0	4.6	3.7	75.8	2.2

* Significant difference ($P < 0.05$).

Experiment 2

Pitfall trap sampling. The average numbers of specimens of selected arthropod categories sampled in pitfall traps on each collecting date in Experiment 2 are shown in Appendix Table 2 and graphed in Figures 19 through 31. Since collecting dates at St. Gabriel and Ben Hur Farm differed prior to July 15 and sample numbers from the latter area were small, data from Ben Hur Farm were not graphed for collecting dates prior to July 15. Numbers of *Cyphomyrmex rimosus*, *Labidura riparia*, and Diplopoda were not graphed because their numbers were extremely small.

Between May 25 and June 1 there were higher numbers ($P<0.05$) of unidentified Lycosidae of 4-8 mm. in length in the pastures planned for mirex treatment compared to the pastures to be left untreated (Figure 21). Otherwise no significant differences between planned treatment areas were detected. It was concluded that the epigeal arthropod communities were generally uniform in the study areas prior to the mirex treatment.

Starting with the June 15 collections, there was a significant reduction of numbers of *S. invicta* in pastures at St. Gabriel that had been treated with mirex 15 days previously ($P<0.01$). The numbers of *S. invicta* were significantly higher in the untreated pastures than in the mirex-treated pastures through the post-treatment period until August 24, except in samples collected June 22 and July 6 at Ben Hur Farm. The numbers of samples collected the latter 2 dates were evidentally too small to determine whether or not differences observed were statistically significant. Pitfall samples after August 24 indicated that *S. invicta* had repopulated the mirex-treated areas.

Pitfall trap data showed isolated increases in spider categories ($P<0.05$) in mirex-treated pastures compared to untreated pastures.

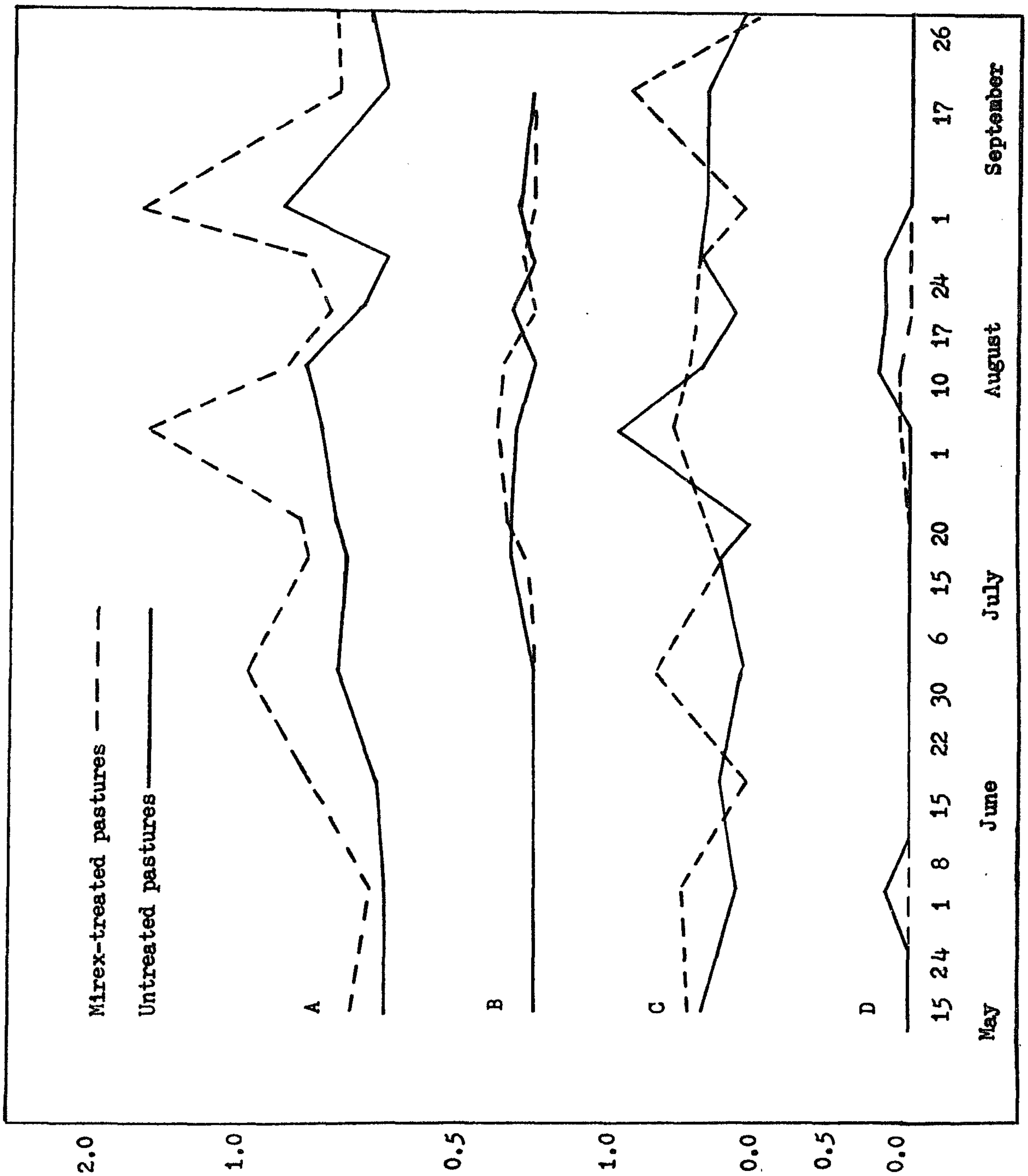


Figure 19. Average numbers of (A) sac spiders, _Trachelus deceptus_ (Banks), and wolf spiders: (B) _Lycosa rabida_ Walkenaer (C) _Lycosa riparia-helluo_ complex, and (D) _Lycosa carolinensis_ Walkenaer per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

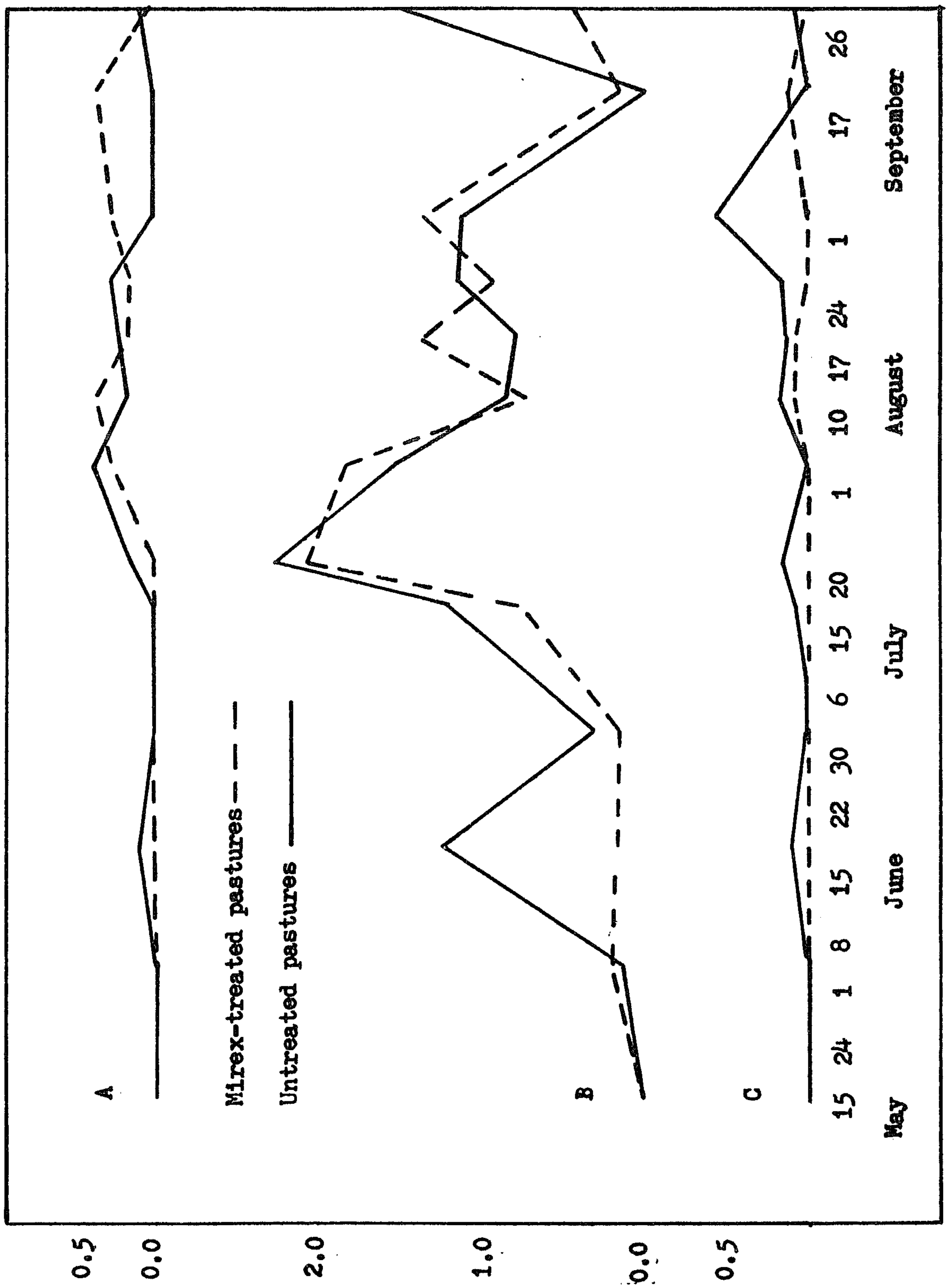
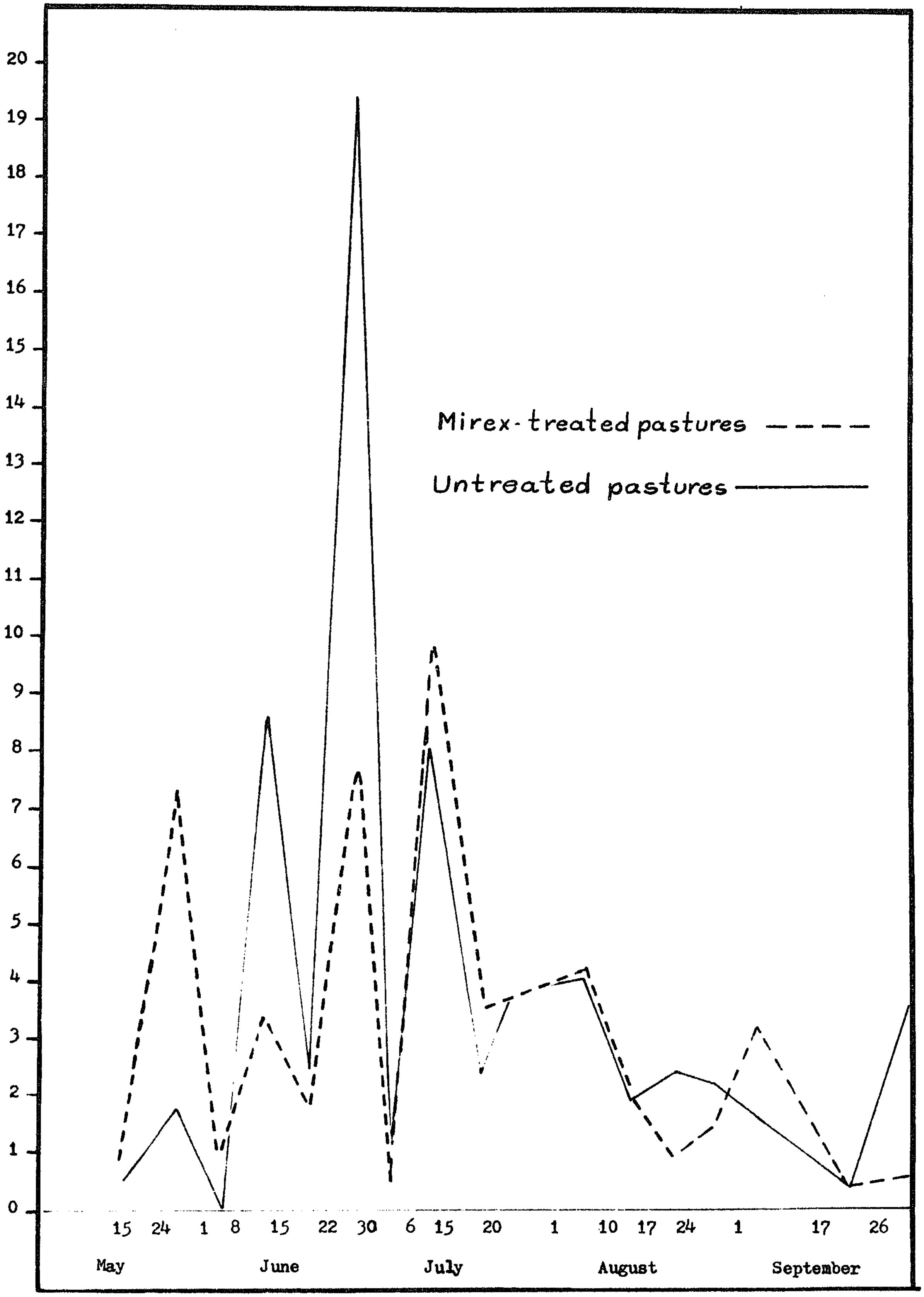


Figure 20. Average numbers of wolf spiders: (A) Pirata spp., (B) Pardosa delicatula-milvina complex, and (C) Schizocosa avida (Walkenaer) per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

Figure 21. Average numbers of unidentified Lycosidae between 4 and 8 mm. long per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973



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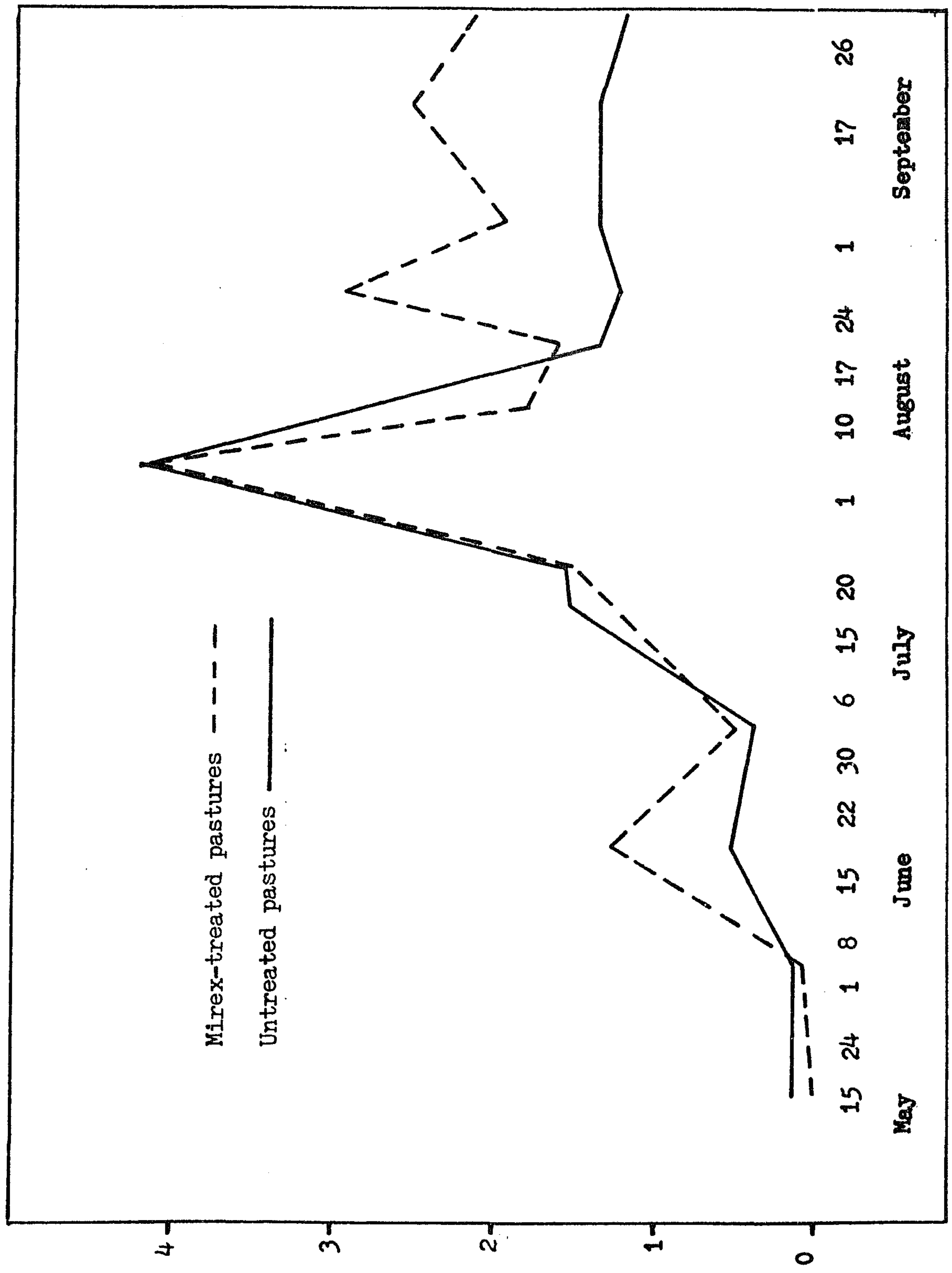

Figure 22. Average numbers of unidentified Lycosidae under 4 mm. long per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

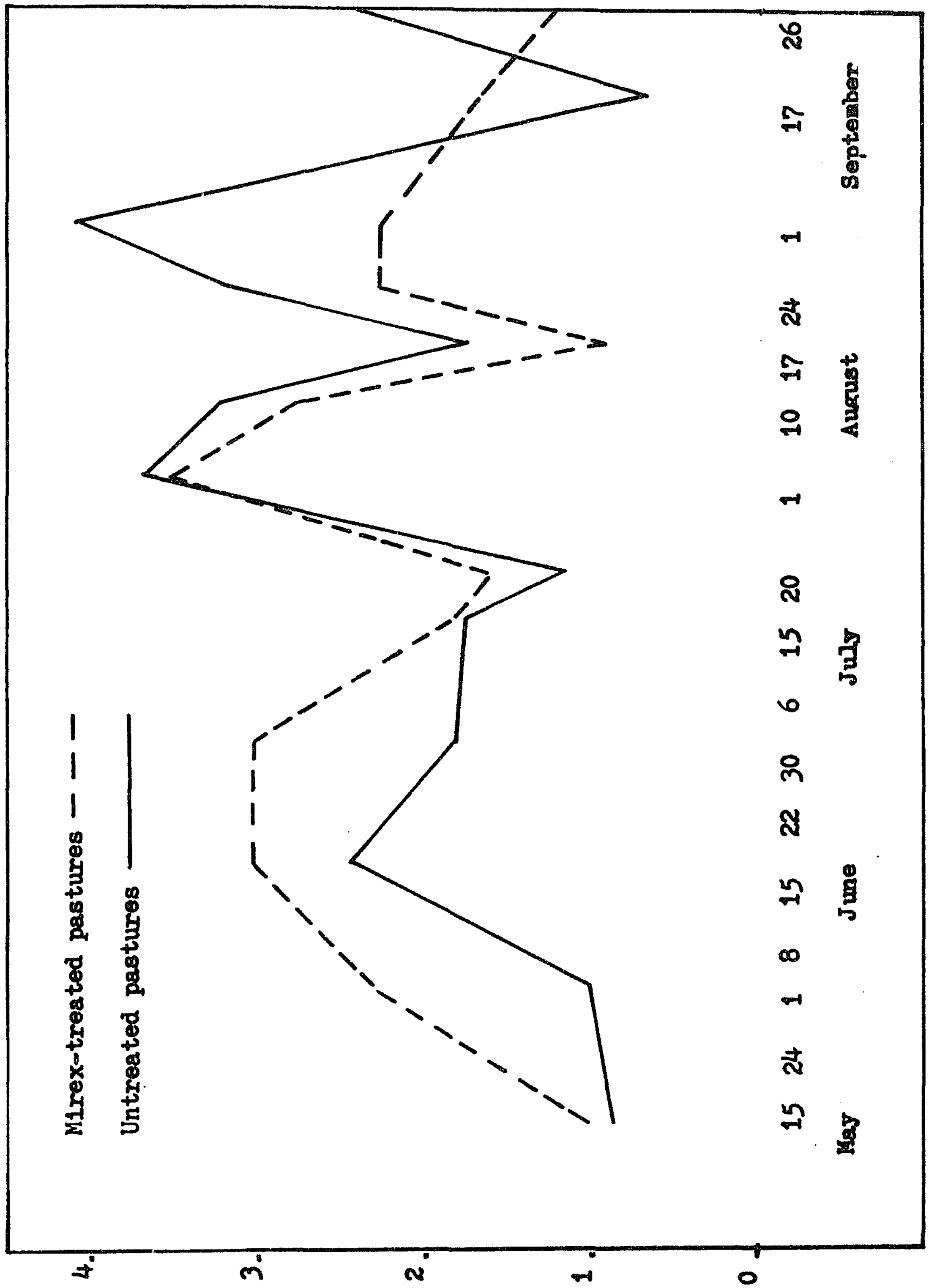

Figure 23. Average numbers of unidentified Araneae per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

Figure 24. Average numbers of (A) ringlegged earwigs, *Euborellia annulipes* (Lucas), (B) crickets, *Gryllus* spp., and (C) unidentified Gryllidae adults per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

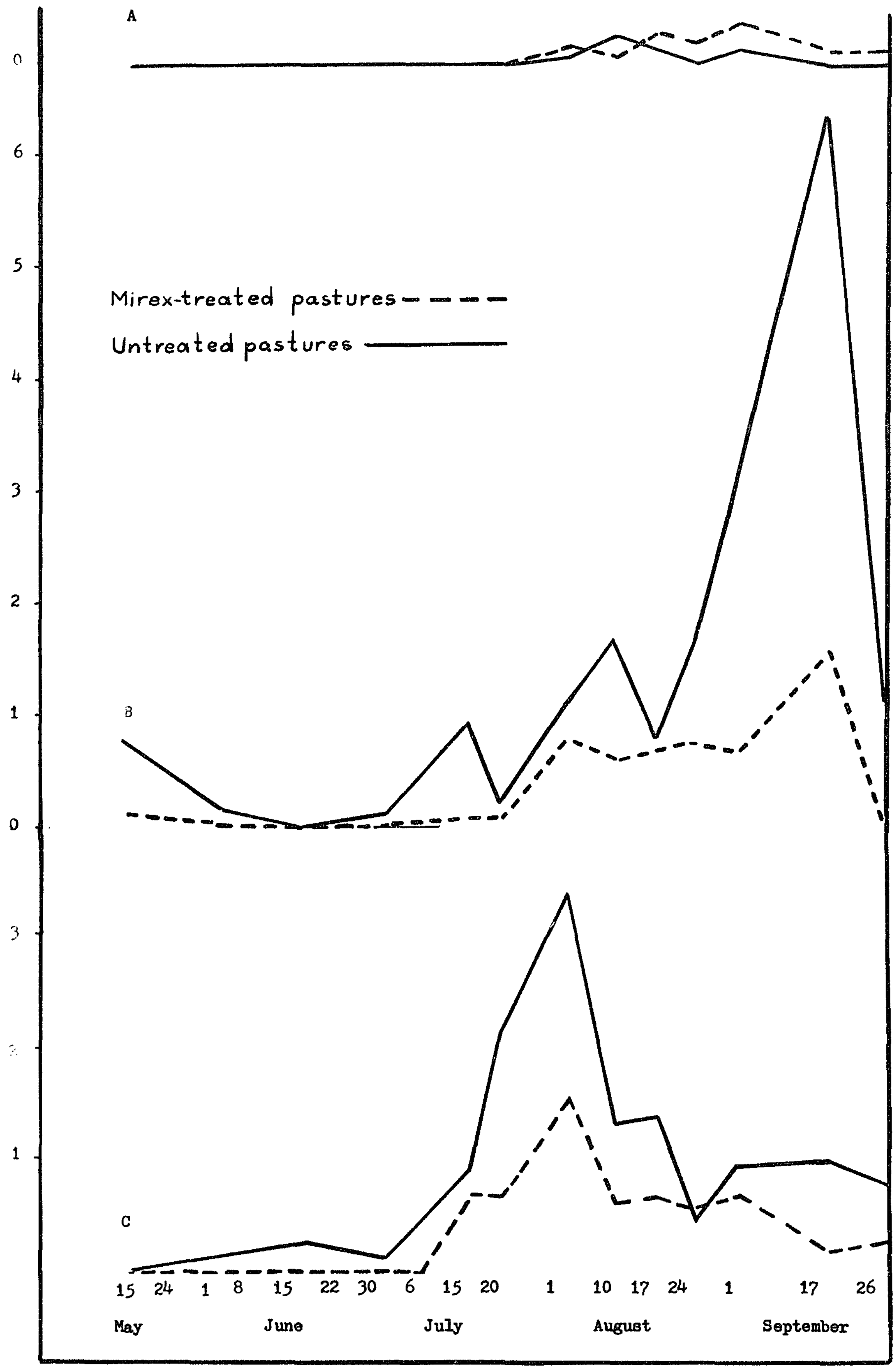
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Figure 25. Average numbers of Gryllidae nymphs per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

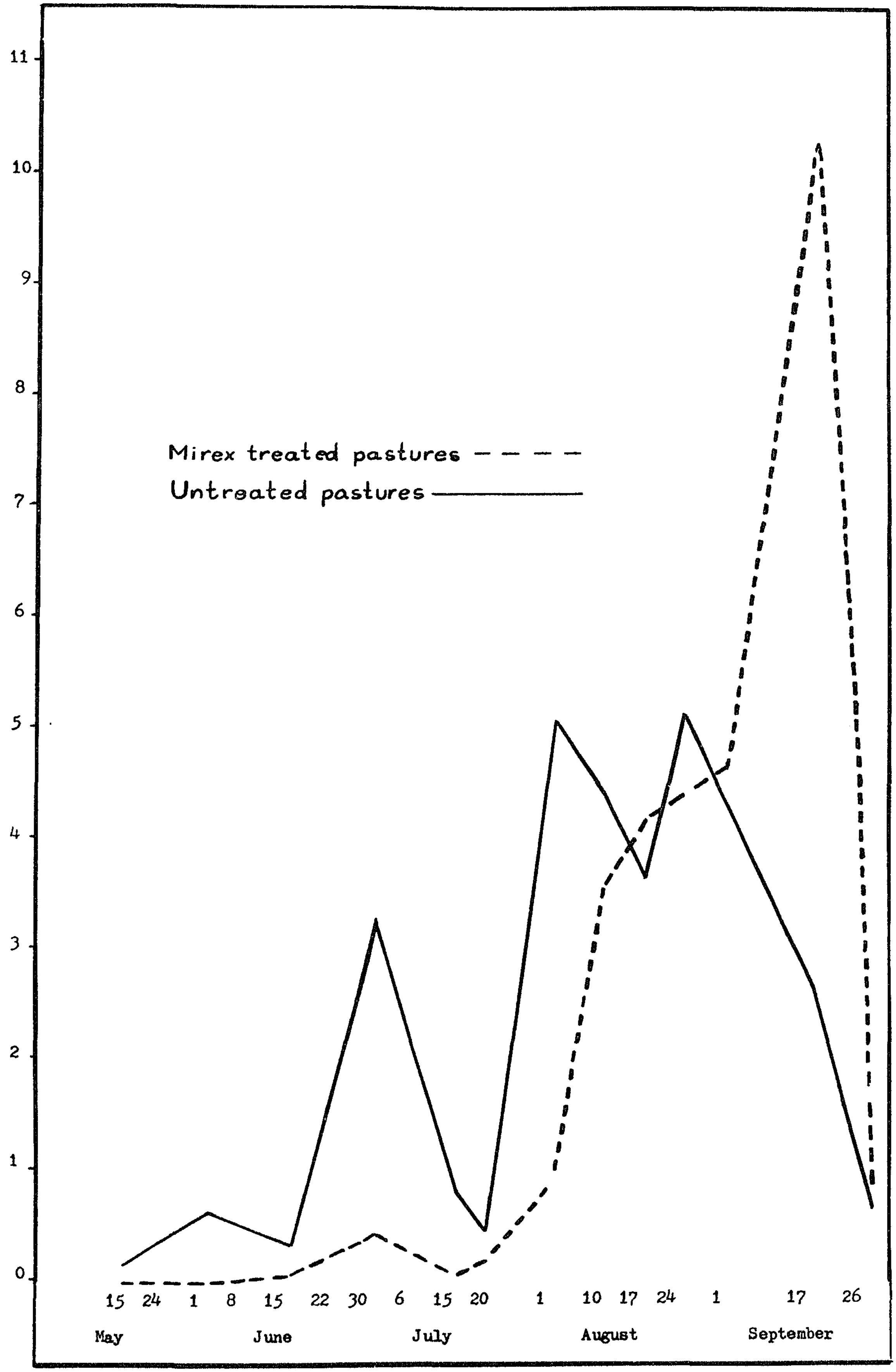

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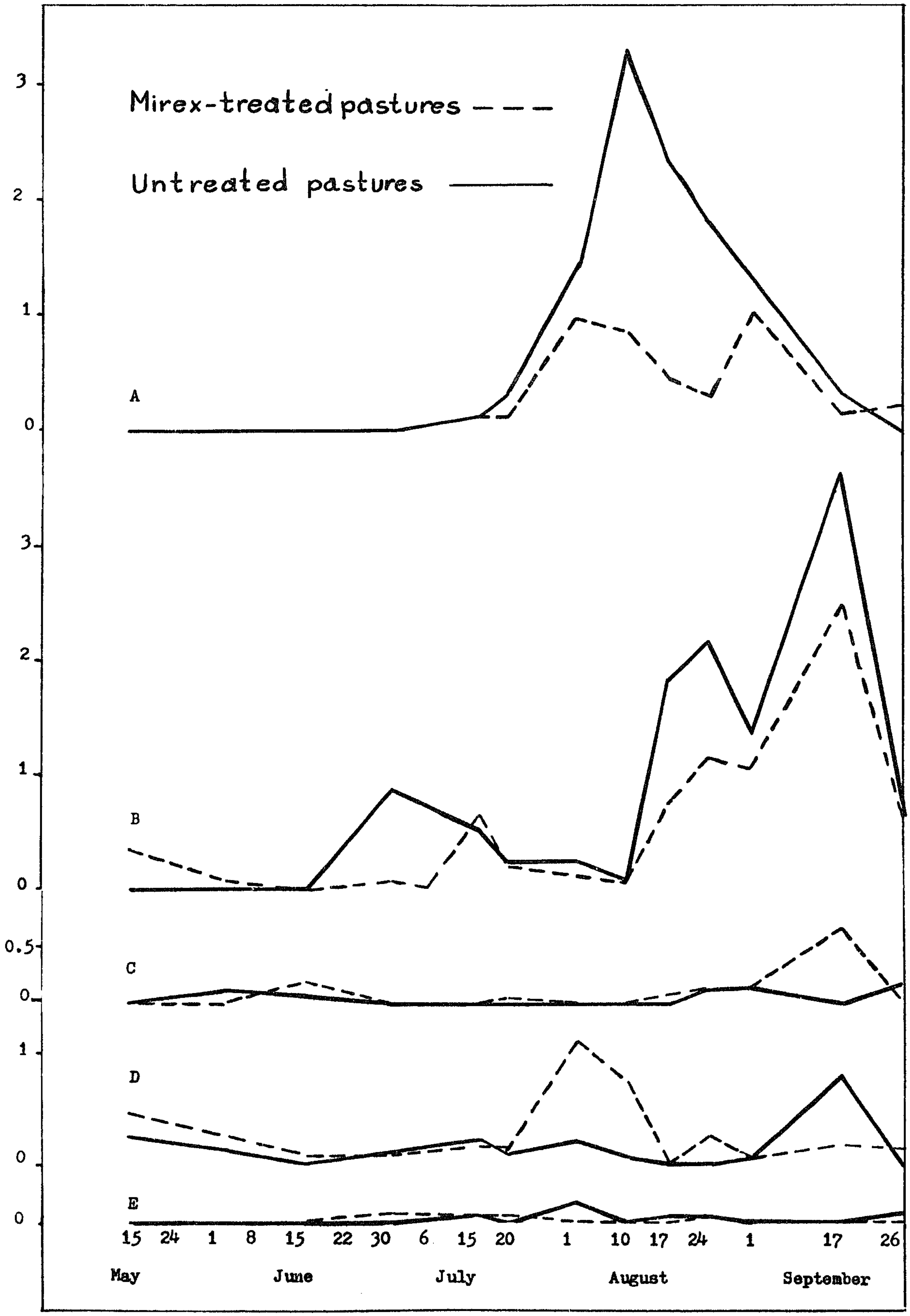
Figure 26. Average numbers of (A) ambrosia beetles, *Xyleborinus saxeseni* (Ratzeburg), (B) rove beetles, Staphylinidae, (C) weevils, *Sphenophorus* spp., (D) ground beetles, Carabidae, and (E) tiger beetles, *Megacephala virginica* Latreille per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.


Mirex-treated pastures
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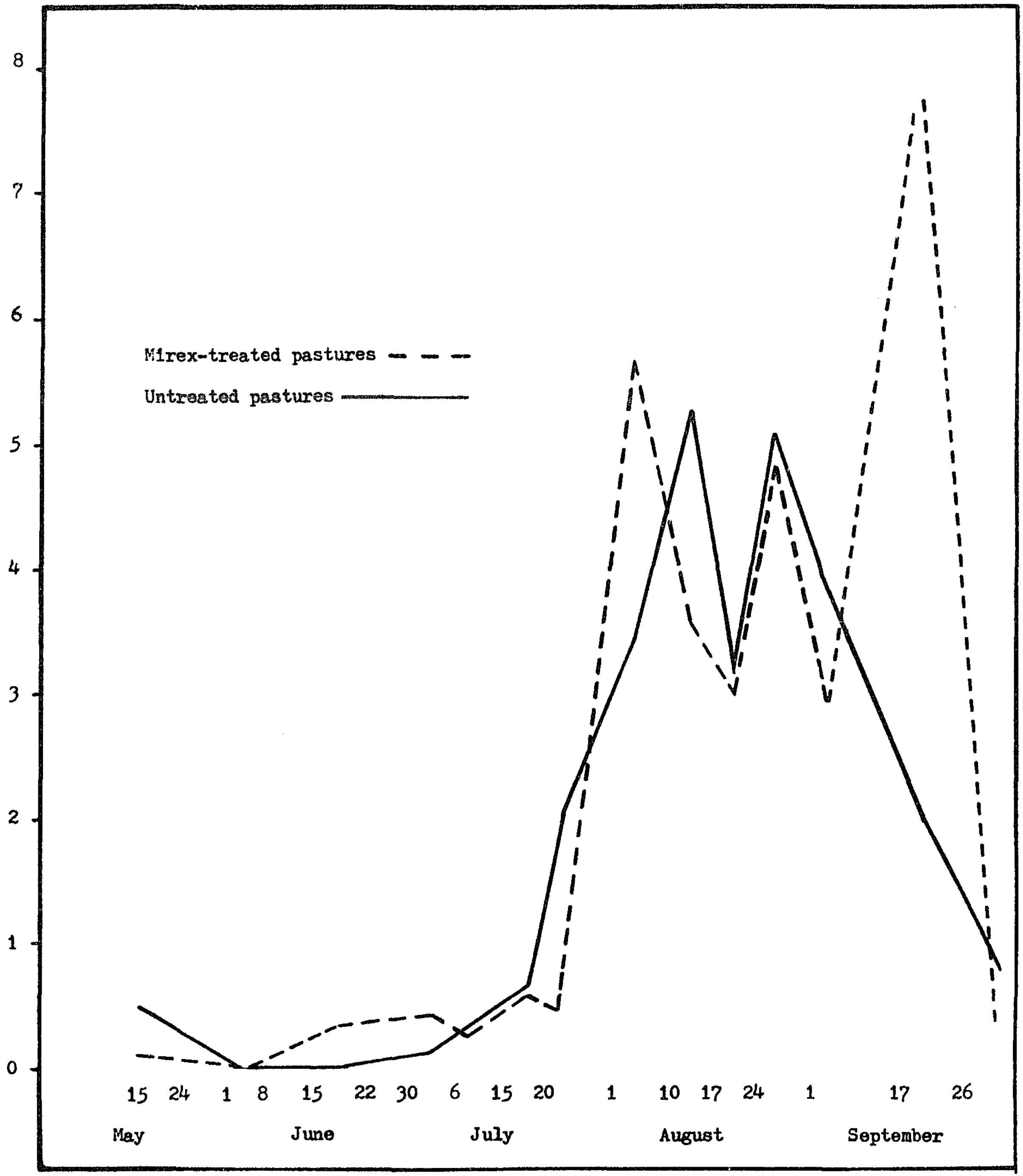

Figure 27. Average numbers of ant-like flower beetles, Vacusus vicinus (LaFerte) per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

Figure 28. Average numbers of (A) root-feeding beetles, *Monotoma picipes* Herbst, and (B) flat bark beetles, *Ahasverus rectus* (LeConte) per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

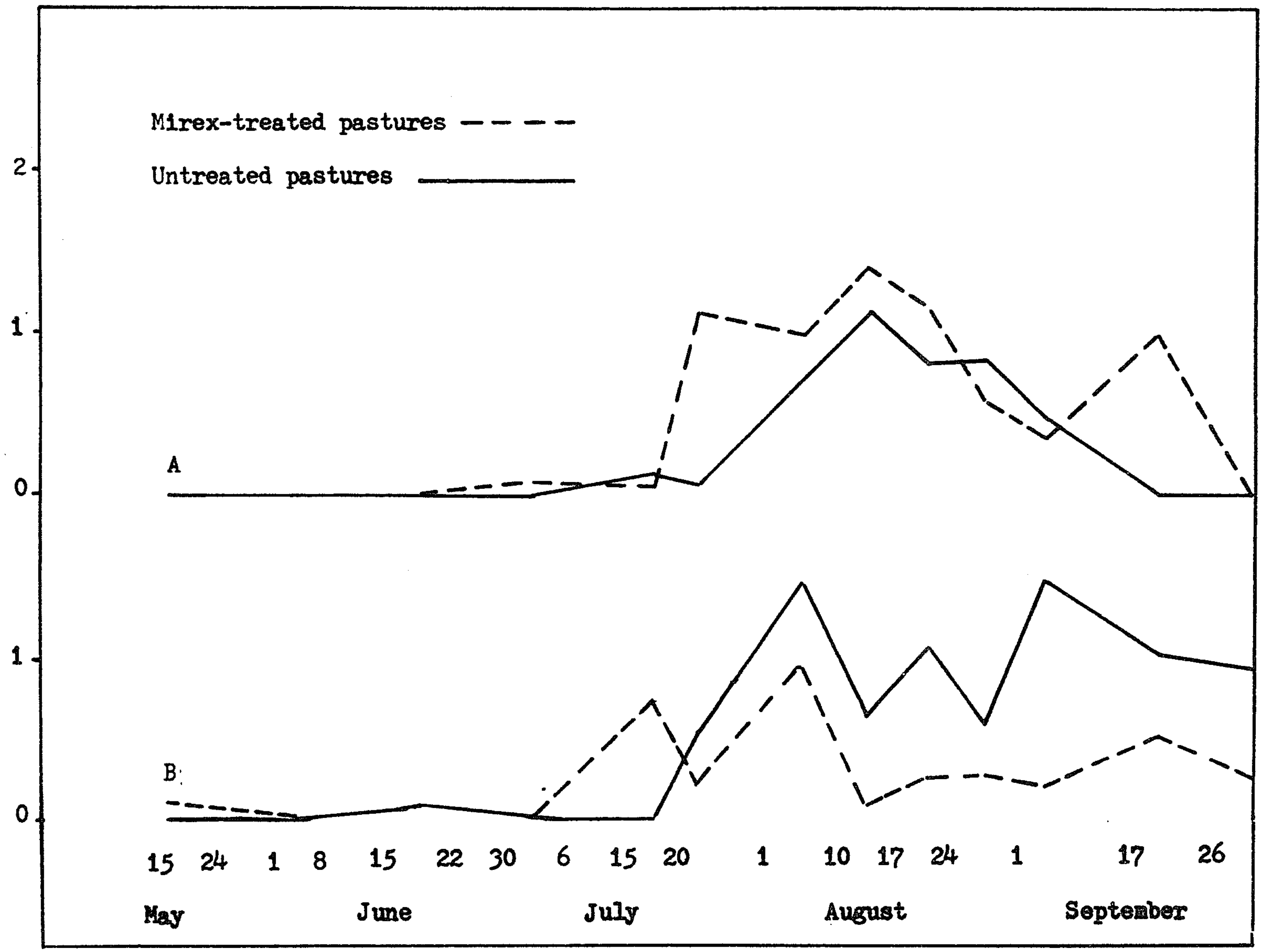
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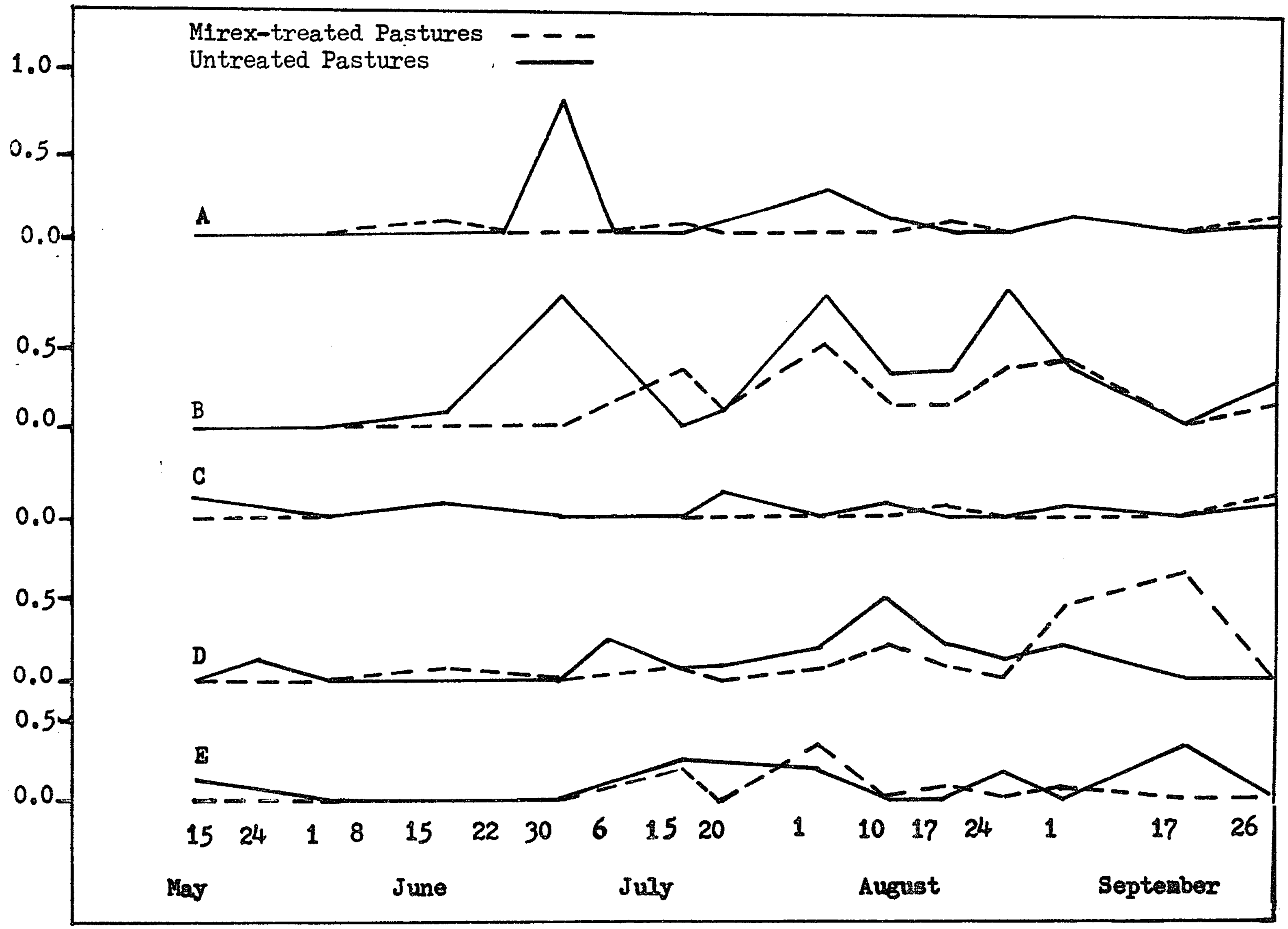
Figure 29. Average numbers of (A) dung beetles, _Aphodius lividus_ (Olivier), (B) Aphodiinae, (C) sugarcane beetles, _Euetheola rugiceps_ (LeConte), (D) fall armyworms, _Spodoptera frugiperda_ (J.E. Smith), and (E) centipedes, Chilopoda per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.



Mirex-treated Pastures
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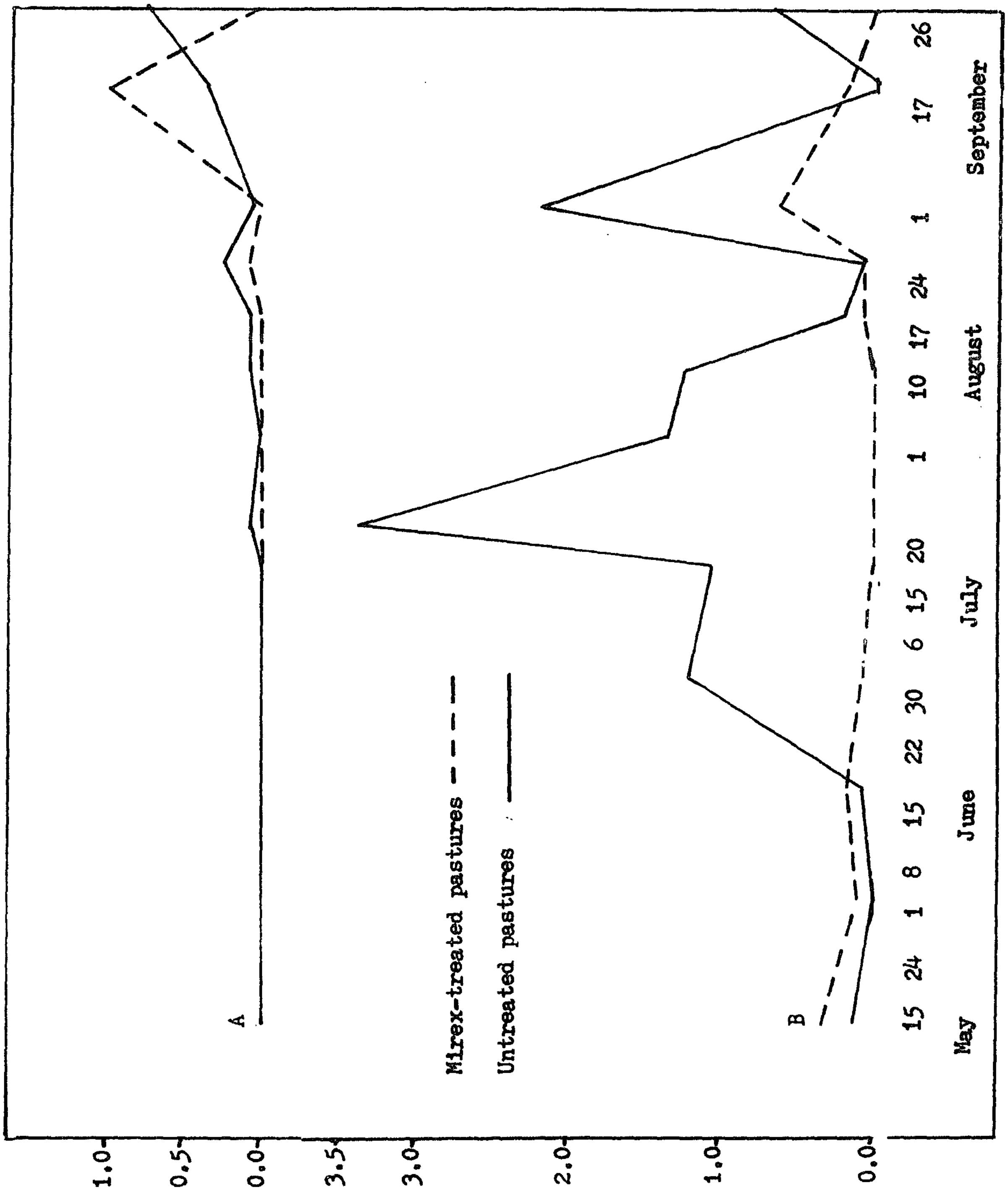
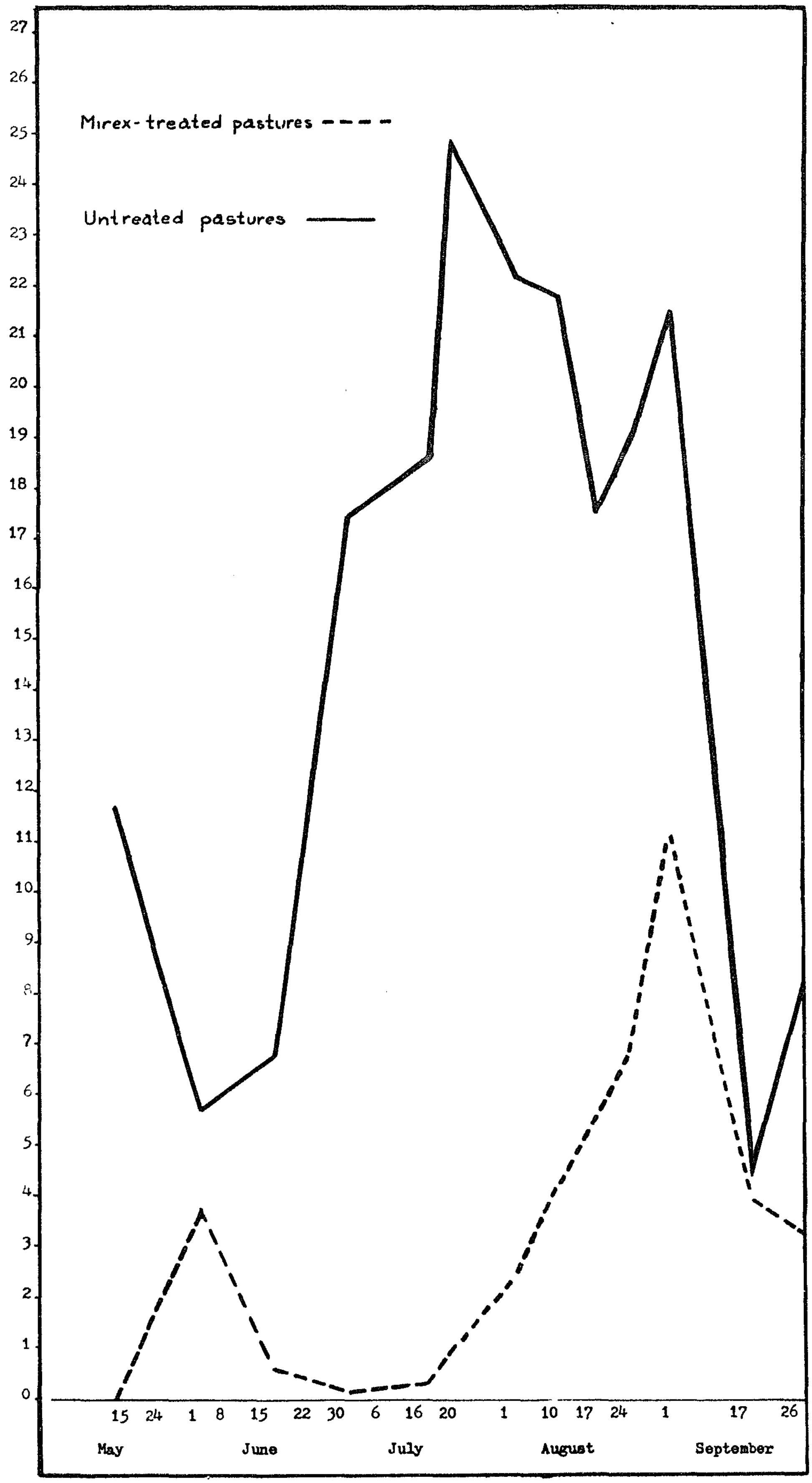


Figure 30. Average numbers of (A) ponerine ants, Hypoponera opaciceps (Mayr) and (B) formicine ants, Nylanderia spp. per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.

Figure 31. Average numbers of red imported fire ants, *Solenopsis invicta* Buren, per collecting date in pitfall traps from mirex-treated and untreated pastures at St. Gabriel and Ben Hur Farm, Louisiana, 1973.


Mirex-treated pastures
Untreated pastures
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15 24 1 8 15 22 30 6 16 20 1 10 17 24 1 17 26
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Unidentified Lycosidae less than 4 mm. in length were more numerous in mirex-treated areas than untreated areas ($P<0.05$) in samples from June 15 and August 24 (Figure 22). Sac spiders, Trachelus deceptus (Banks), were in higher numbers ($P<0.05$) in samples collected from mirex-treated areas than in those from untreated areas on August 1 and 24. Small wolf spiders, Pirata spp., were in higher numbers ($P<0.05$) in samples collected from mirex-treated areas than in samples from untreated areas on September 1 (Figure 20). Wolf spiders, Schizocosa avida (Walkenaer) and Lycosa riparia-helluo complex, were in higher numbers ($P<0.05$) in samples collected from untreated areas than in samples from mirex-treated areas on September 1 (Figures 19 and 20). Numbers of spiders of the Pardosa delicatula-milvina complex were higher in untreated areas ($P<0.05$) than in mirex-treated areas in samples collected September 26 (Figure 20).

The results of Experiments 1 and 2 agree in that components of the epigeal spider community were occasionally collected in higher numbers in the mirex-treated than in untreated areas during the summer months. Various components of the spider community may have increased in spurts in the treated areas due to the absence of S. invicta. During September and October, relatively lower numbers of certain components of the epigeal spider community were occasionally collected in mirex-treated areas in Experiment 2. Some components of the spider community appear to have experienced short-term decreases in populations, possibly due to repopulation of the treated areas by S. invicta or to the accumulation of mirex to toxic levels in some spiders.

Higher numbers ($P<0.05$) of Vacusus vicinus were collected in mirex-treated than in untreated areas on July 15 and September 1 (Figure 24). Lower numbers of Ahasverus rectus (LeConte) ($P<0.05$) were collected in mirex-treated areas than in untreated areas on August 10 and September 1 (Figure 28).

The results of analyzing combined data from June 15 to August 24 showed that there were generally higher numbers of Trachelus deceptus (Banks) (Figure 19) and Carabidae (Figure 26) in the mirex-treated areas than in the untreated areas ($P<0.05$). An increase in Carabidae in mirex-treated areas compared to untreated areas was detected in certain collecting periods in Experiment 1. An increase in T. deceptus was not detected in Experiment 1.

Lower numbers of Nylanderia spp. (Figure 30), of Schizocosa avida (Figure 20), Gryllus spp. and unidentified Gryllidae (Figure 24), Xyleborinus saxeseni, Staphylinidae (Figure 26), and Aphodiinae (Figure 29) were detected in mirex-treated areas than in untreated areas between June 25 and August 24 ($P<0.05$). Relatively fewer numbers of these taxa in mirex-treated areas compared to untreated areas were not detected in Experiment 1, except that Aphodius lividus occurred in significantly lower numbers in pitfall traps collected October 21, and numbers of Aphodiinae were lower in dung pats exposed 6 days in mirex-treated areas than in comparable dung pats from untreated areas.

The higher numbers of T. deceptus and Carabidae in mirex-treated pastures than in untreated pastures may have been due to the absence of competition and/or predation by S. invicta. The lower numbers of Schizocosa avida, Nylanderia spp., Xyleborinus saxeseni, Staphylinidae, Aphodiinae, and Gryllidae may indicate that densities of these arthropods were thinned out by accumulation of toxic levels of mirex. It may be significant that scavengers and decomposers are included in the last 3 mentioned taxonomic groups.

Bait station sampling. In sampling ant populations by baits 1-½ months after the mirex-bait treatment, a sharp difference was found between populations of S. invicta in treated and untreated pastures. Suppression of S. invicta was drastic in pastures 200, 210, 220, and 230, (treated) where 92 to 100 percent of the baits attracted fewer than 10 S. invicta workers, compared to baits in pastures 100, 110, 120, and 130, (untreated) where 62 to 100 percent of the baits attracted 50 or more S. invicta workers. In pasture 140 (treated), where baits were exposed to full sunlight, 19 percent of the baits attracted less than 10 ants (Table 8).

Suppression of S. invicta populations was less pronounced in pasture 250, where 16 percent of the baits attracted more than 50 ants. Since pitfall traps were not maintained in this pasture, and nest counts were not made, bait samples provided the only data for S. invicta populations. Most of the baits that attracted S. invicta workers were at the north end of the pasture. Since the mirex-bait was applied in east-west swaths working towards the north, the applicator probably put out less bait as the amount of material became low in the hopper towards the end of the treatment procedure. The average rate, however, was 2.46 pounds per acre (Table 3).

Baits were set out about 3-½ months after the mirex treatment in 3 treated and 3 untreated pastures. It was found that S. invicta populations were lower in treated than in untreated areas, but had increased during the post-treatment period (Table 8). Sixty to 66 percent of the baits in the treated pastures attracted 50 or more S. invicta workers in about 1 hour, compared to baits in the untreated pastures, 85 to 99 percent of which attracted 50 or more S. invicta workers.

Table 8. Percentages of bait samples visited by 0-10, 11-50, and 50+ *Solenopsis invicta* workers in pastures in Experiment 2, St. Gabriel and Ben Hur Farm, Louisiana.

	Untreated Pastures				Mirex-treated Pastures		
Pasture Number	Nos. of S. invicta at bait			Pasture Number	Nos. of S. invicta at bait		
	0-10	11-50	50+		0-10	11-50	50+
July 17-25, 1973							
100	0	0	100	200	100	0	0
110	0	0	100	210	100	0	0
120	4	4	92	220	100	0	0
130	0	0	100	230	92	8	0
140	19	19	62	240	100	0	0
150	0	17	83	250	76	8	16
September 19-26, 1973							
100	15	0	85	200	40	0	60
120	0	8	92	220	26	8	66
150	1	0	99	250	11	29	60

S. invicta workers attracted to baits in treated areas with the exception of pasture 250 tended to be smaller workers, while those visiting baits in pasture 250 and in untreated pastures were of mixed sizes. This indicates that ants in treated pastures 3-½ months after the mirex-bait application were generally members of incipient colonies.

Pasture 250 continued to have higher *S. invicta* populations than other treated pastures. Eleven percent of the baits in pasture 250 were not visited by ants, while in the other 2 pastures sampled 26 and 40 percent, respectively, of the baits were not visited.

Ant species other than *S. invicta* were sometimes observed to visit the baits. Observations on these ants with respect to their inter-relationships with *S. invicta* are reported further on in the present study.

Sweep net samples. Average numbers of selected arthropod categories in paired sweep net samples from mirex-treated and untreated Bermuda grass pastures at St. Gabriel and Ben Hur Farm are shown in Table 9.

Five categories were represented by significantly higher numbers in samples from the mirex-treated pastures than in samples from untreated pastures. There was an average of 6.3 chinch bugs, *Blissus insularis* Barber per sample from the mirex-treated pastures compared to 2.3 per sample from the untreated pastures ($P<0.05$). There was an average of 4.7 braconid wasps of the genus *Apanteles* in samples from the mirex-treated pastures compared to 1.25 per sample from the untreated pastures ($P<0.01$). These wasps are parasitic on various species of Lepidoptera, including armyworms, *Spodoptera frugiperda* (J.E. Smith) (Muesebeck, et al. 1951). The higher numbers of these wasps in mirex-treated areas may have been due to greater host availability. However, no significant differences between treatments were detected in numbers of Lepidoptera in sweep net

Table 9. Average numbers of selected arthropod categories per 120 sweeps in mirex-treated and untreated Bermuda grass pastures, Experiment 2, St. Gabriel and Ben Hur Farm.

Taxon or category.	Untreated Pastures	Mirex-Tr. Pastures
Conocephalus fasciatus fasciatus	2.8	4.2
Other grasshoppers (Mostly *Orphulella palidna palidna*)	0.7	0.8
Grasshopper nymphs	37.1	42.0
Trigonotylus pulcher		
adults	157.5	106.7
nymphs	190.3	140.2
Blissus insularis	2.3*	6.3*
Orthaea longulus	6.6	5.2
Ligyrocorus sp.	2.7	4.4
Oebalus pugnax	0.5	0.8
Leafhopper nymphs	118.2	113.8
Carneocephala flavipes	7.1	9.4
Exitanus exitiosa	44.9	60.2
Graminella nigrifrons	140.8	133.5
Draeculacephala spp.	28.4	21.4
Chlorotettix viridis	12.9	9.9
Prosapia bicincta	3.3	2.2
Fulgoroidea	27.5*	15.1*
Spissistilus festinus	6.7	5.5
Diabrotica balteata	0.6	0.8
Diabrotica undecimpunctata howardi	0.3	0.5

Table 9 (continued).

Taxon or category	Untreated Pastures	Mirex-Tr. Pastures
Chaetocnema minuta	13.2	19.4
Longitarsus sp.	1.7	2.1
Scymnus loewii	2.4	3.1
Chelonus texanus	0.1	0.1
Diadegma pattoni	0.4	0.4
Rogas sp.	0.7	0.5
Apanteles spp.	1.2**	4.7**
Spilochalcis hirtifemora	0.1	0.2
Euplectrus	0.2	0.5
Solenopsis invicta	3.4	5.6
Nylanderia spp.	0.6	0.06
Monomorium minimum	1.7	0
Hypoponera opaciceps	0.1*	0*
Dryinidae	0.3**	0.05**
Unidentified Hymenoptera	14.3	15.3
Monochaetoscinella nigricornis	22.1	18.8
Ceropsilopa mellipes	20.7	25.9
Leptopsilopa atrimana	2.6	3.1
Sarcophagidae (Mostly *Ravinia derelicta*)	6.2*	10.1*
Mesograpta marginata	1.6	1.1
Pipunculidae	0.4*	0.9*

Table 9 (continued).

Taxon or category	Untreated Pastures	Mirex-Tr. Pastures
Unidentifed Diptera (Includes 42% Hippelates spp. based on 11 120-sweep samples)	228.6	202.1
Lepidoptera larvae	5.8	7.9
Araneae	36.6	45.1

samples, nor of Spodoptera frugiperda in pitfall traps. Some species of Apanteles pupate on plants (Swan and Papp 1972) and it is possible that in this stage they were susceptible to predation by S. invicta in untreated pastures.

There was an average of 10.1 Sarcophagidae in samples from mirex-treated pastures and 6.2 per sample from untreated pastures ($P<0.05$). Most of these were identified as Ravinia derelicta (Walker), a species often observed larvipositing on fresh cattle manure. No significant differences between treatments in numbers of sarcophagid immatures in dung pats were detected. This may have been because dung-breeding species of this family tend to pupate outside of the dung (Mohr 1943).

Big-headed flies, Pipunculidae, averaged 0.94 per sample from the mirex-treated areas and 0.36 per sample from untreated areas ($P<0.05$). Species of Pipunculidae included Tomosvaryella subvirescens (Loew) T. coquilletti (Kertesz), and Tomosvaryella sp. Larvae of T. subvirescens parasitize leafhoppers. Pipunculidae pupate on plants (Swan and Papp 1972). Since no significant differences between treatments in the numbers of 5 of the most abundant species of leafhoppers were detected, it is unlikely that differences in host availability influenced populations of Pipunculidae. It may be that S. invicta preyed on pupae of these flies in the treated areas.

Three taxa were represented by significantly higher numbers in sweep net samples from untreated areas compared to samples from mirex-treated areas. There were 27.5 specimens of Fulgoroidea per sample from untreated areas and 15.1 specimens per sample from mirex-treated areas ($P<0.05$). A natural enemy of Fulgoroidea that is ordinarily regulated by S. invicta may have increased in the mirex-treated areas.

There was an average of 0.3 Dryinidae per sample from the untreated pastures and 0.06 per sample from the mirex-treated pastures ($P<0.01$). Species tentatively identified from these pastures were *Pseudogonatopus iowensis* Fenton, *Neogonatopus mimoides* Perkins, *Neogonatopus brunnescens* Perkins, *Neogonatopus* sp. and *Gonatopus* sp. No authority was available to confirm identifications of Dryinidae, and the family is in need of revision (Evans 1974). Dryinidae that have been studied parasitize Cicadellidae, Fulgoroidea, or Membracidae (Borror and DeLong 1971). Possibly the greater availability of hosts resulted in more Dryinidae in the mirex-treated pastures.

Hypoponera opaciceps Mayr, a ponerine ant, occurred in lower numbers ($P<0.05$) in sweep net samples from the mirex-treated pastures compared to samples from the untreated pastures. *Monomorium minimum* (Buckley) occurred in samples from untreated areas, but were absent in samples from mirex-treated areas. Although the difference was not statistically significant, the absence of this ant from the samples from the treated areas suggests that the effects of mirex-bait applications on populations of the ant should be investigated using a different technique than sweeping transects. Sweep net samples revealed no significant difference in numbers of *S. invicta* nor *Nylanderia* spp. between treatments. Most of the specimens of *S. invicta* were small workers. Clusters of small workers of incipient colonies probably biased the samples. It was concluded on the basis of data from pitfall traps, bait stations, nest counts, and sweep net transects that the latter technique yielded biased samples of ant populations, and probably should not be employed in sampling social insects.

None of the predator populations in the herb layer were found to increase in the absence of _S. invicta_. A long-horned grasshopper, _Conocephalus fasciatus fasciatus_ (DeGeer), which preys upon various insects and their eggs (Nilakhe 1974); a lady beetle, _Scymnus loewii_ Mulsant; and Araneae were relatively frequent in both treated and untreated areas. The most common genera of Araneae of the herb layer were _Misumenops_ (Thomisidae), _Oxyopes_ (Oxyopidae), _Pellenes_ (Salticidae), _Neoscona_, _Acanthepeira_, and _Singa_ (Araneidae). Several species of lady beetles and other predators were identified (Table 2) but their frequencies in treated and untreated areas were low. Thus, _S. invicta_ apparently did not influence populations of predators of the herb layer community.

Dung pat samples. The numbers of selected insect categories in manure samples from mirex-treated and untreated pastures are shown in Table 7. In samples from pastures 110 and 210 in June, the average number of horn fly pupae was 5 times higher in samples from the treated pastures than from the untreated pastures ($P<0.05$). The average number of Staphylinidae other than _Philonthus_ sp. was 15 times greater in the treated than in the untreated pastures ($P<0.05$). _Oxytelus_ was frequent, but other genera may have been represented in the pooled category of Staphylinidae.

It is probable that the high densities of horn fly pupae brought about the recruitment of large numbers of _S. invicta_ workers to dung pats in the untreated areas, resulting in predation upon Staphylinidae as well as on the fly pupae.

No significant reduction in Aphodiinae in dung pats from the mirex-treated areas was detected, although fewer numbers of the family were collected in pitfall traps.

There were no significant differences detected in numbers of insects of any of the selected categories in dung samples from pastures 120 and

220 which were sampled from June 29 to August 31. The cattle in these pastures had access to a dust bag, and adult horn fly populations were uniformly low.

Field Observations of Ant Behavior

Field observations of the activities of ants and their relationships with each other and with other insects were made in an attempt to better understand sample data.

Predatory activity of S. invicta. The following observations were made in the afternoon of August 16, 1972, during a 2-hour period.

A scarab beetle larva, *Diplotaxis* sp. (length 12 mm.) was exposed on the soil surface near a nest of *S. invicta*. One S. invicta worker encountered the larva and stung it. Two other ants encountered the larva and also attacked it. The movements of the larva were at first violent, but became feeble within 3 minutes. The 3 ants started to drag the larva towards the nest over bare soil at the rate of about 1 cm. per minute. The activity of the ants was unorganized, and occasionally 1 or 2 of the ants would climb on the larva and explore it. In such instances, a single worker ant was able to drag the larva with the 2 ants mounted on it.

A geometrid larva was observed on bare soil near the nest. Each time an ant encountered it, it flipped away. One ant seized it and stung it. Three other ants that happened to arrive joined the attack. They began to drag the larva towards the nest. Its movements were violent, but soon became feeble.

A small green adult leafhopper that was resting on bare soil was seized by an ant and dragged to the nest.

A caterpillar 9 mm. in length was discovered immobilized apparently by an ant sting, although no ant was near it. About 50 cm. away a column of 9 *S. invicta* workers was moving directly towards the caterpillar. Upon arriving at the caterpillar, 5 ants began to drag it in the direction from which they had come (undoubtedly, the nest). The other 4 ants wandered off. The grass made it difficult for the ants to drag the caterpillar. They moved at a rate of about 3 cm. per minute.

Near a dung pat, 1 ant was carrying an elytron of an aphodine beetle. Minutes later, 3 ants came from the same direction with a dead aphodine which had its wings removed. A beetle, Sphaeridium sp. (Hydrophilidae) was observed resting on a dung pat with its wings extended, while a worker ant was wandering on the same pat. The ant encountered the beetle and attempted to seize and sting it. The beetle quickly lowered its wings. The ant again attempted to sting it, but the sting apparently did not pierce the cuticle. The ant wandered off to another area. The beetle then began to burrow into the dung.

Three ants were observed attacking a cricket nymph, which attempted to escape by burrowing into the soil. For several minutes the ants struggled until they had pulled it free of the soil. One of the ants flipped the cricket nymph over so that its legs were out of contact with the ground and carried it in this position.

The larvae of a neuropteran were observed on an oak trunk. Each bore a protective covering of particles of bark and lichens. One S. invicta worker encountered a larva on the trunk of the tree and attempted to sting the protective covering. After several attempts, the ant wandered off, and the neuropteran continued walking without having been disturbed by the ant's attack.

Based on these few observations, S. invicta workers do not discriminate among the arthropods they attack. Heavily armed beetles, insects protected by coverings, and highly active insects were attacked. Individual workers did not persist in attempting to capture difficult prey. Difficult prey (*e.g.*, the geometrid larva) may be captured, especially where high densities of ants increase the chances of successful capture. *S. invicta* became most persistent at immobile food sources, as shown by bait sampling. Once active prey were immobilized, the ants persisted in their efforts to transport it, even when it was large and cumbersome. Pupae exposed to predation, such as *Haematobia irritans* pupae in the soil-dung interface would seem to constitute an ideal food source for *S. invicta*.

Relationships between Solenopsis invicta and other ant species. The following species of ants were found in open pastures: *Nylanderia melanderi arenivaga* (Wheeler), *Nylanderia parvula* Wheeler, *Hypoponera opaciceps* (Mayr), *Pheidole floridana* Emery, *Cyphomyrmex rimosus* (Spinola), *Monomorium minimum* (Buckley), *Solenopsis molesta* (Say), and *Solenopsis invicta*.

Species of *Nylanderia* were not differentiated. Whitcomb, et al. (1972) stated that species of *Nylanderia* were among the most aggressive Formicinae in Florida. The are adapted to live in nests colonized by *S. invicta* (O'Neil 1974). Invasions of new areas in Arkansas by *S. invicta* appeared to favor populations of *Nylanderia* spp. (Roe 1974). The species was second to *S. invicta* in numbers collected in pitfall traps in pastures at St. Gabriel and Ben Hur Farm (Appendix Tables 1 and 2).

Nylanderia spp. workers were observed only once at soybean oil baits. Of 50 nests opened on the air strip at St. Gabriel, about half were occupied by *S. invicta*, a fourth were abandoned, and a fourth were occupied by *Nylanderia* spp. In nests opened for examination in pastures, *Nylanderia* spp. were not observed.

Cyphomyrmex _rimosus_ workers were observed foraging in open pastures, often in the vicinity of _S_. _invicta_ nests. They are small and slow-moving, compared to _S_. _invicta_, and the latter appeared to ignore them.

Monomorium _minimum_ workers are 1 mm. long. Of 26 soybean oil baits distributed 1 afternoon, 3 were occupied by 100 or more _M_. _minimum_ at the end of an hour. The other baits were occupied by clusters of 20 to 100 or more _S_. _invicta_ workers. As _S_. _invicta_ workers arrived at a bait occupied by _M_. _minimum_, a few of the latter species raised their abdomens and exuded small white droplets. This action had the result of repelling individual _S_. _invicta_ workers from the bait. As more _S_. _invicta_ workers arrived, however, _M_. _minimum_ workers began to leave singly or several at a time. There was no conflict between the 2 species at this point. A smooth transition took place within 10 minutes in which about 100 _M_. _minimum_ workers were replaced by about 100 _S_. _invicta_ workers.

Of a series of 20 soybean oil baits exposed 1 hour in weedy pastures at St. Gabriel, 18 were occupied by 100 or more _S_. _invicta_, 1 by 9 _Nylanderia_ spp., and 1 by 50 _M_. _minimum_ and 15 _Pheidole_ _floridana_. The latter 2 species occupied different sites at the bait.

Pheidole _floridana_ are tiny ants that apparently occurred in small colonies. They occupied baits quickly when placed in the vicinity of their colonies. They fled from these baits and hid at the slightest disturbance. Through this adaptation they avoided conflict with _S_. _invicta_ at baits. Their food preferences also seemed to differ from those of _S_. _invicta_, since they were attracted to banana peels, which did not attract _S_. _invicta_.

Hypoponera _opaciceps_ were sometimes seen in the vicinity of _S_. _invicta_ nests. One worker was observed carrying a dead fulgorid.

Solenopsis molesta were collected in pitfall traps. One specimen was in a sample from the treated area and 1 from the untreated area. The species was reported to inhabit nests of *S. invicta* and prey on their eggs (O'Neil 1974).

The ant communities of trees scattered throughout the pastures, of fence posts, and of shrubbery along fence lines differed from that of the open pasture. *S. invicta* did not dominate these habitats, but occasinally became active in them.

Crematogaster ashmeadi (Mayr) was the most abundant ant species on water oak, *Quercus nigra* L., and other pasture trees, and appeared to dominate this habitat. *C. ashmeadi* foraged throughout the trees, but in areas not treated with mirex-bait the species was seldom observed to forage lower than 1 meter up from the ground. This coincided with the upper limit to which *S. invicta* workers would forage. On 1 tree the apparent boundary between territories of the 2 species was strewn with *S. invicta* corpses.

In the mirex-treated pastures, the territory of *C. ashmeadi* was expanded to include the ground surrounding the tree for a radius of about 2 meters. *C. ashmeadi* workers were often observed carrying dead arthropods. Meat baits placed in trees were occupied within minutes by 30 or more *C. ashmeadi* workers. *S. invicta* never came to baits placed in trees, even if left for hours. Over a period of a few hours, baits in trees would be cut up and taken to nests by *C. ashmeadi*. Nests of *C. ashmeadi* were in tree holes as low as 1 meter from the ground, but generally were higher.

Cyphomyrmex rimosus (Spinola), which was common in open pastures, foraged on tree trunks to a height of about 2 meters. Nests were sometimes located in tree holes. One entrance observed was about 10 cm. above the ground in a water oak trunk. Old spider webbing blocked the entrance and contained corpses of S. invicta. The relatively small C. rimosus workers moved easily among the strands. About 1 C. rimosus worker entered the nest each minute, and workers left the entrance at about the same rate. Insect parts, bits of algae, and caterpillar feces constituted the foraged material. Often materials were brought out of the nests.

Pheidole floridana Emery was found both in open pastures and on tree trunks. They shared the latter habitat with Leptothorax schaumi Roger. Both species came to fruit baits within minutes. P. floridana would flee the baits at the slightest disturbance, but would return in less than a minute. L. schaumi was slower to leave, and slower to return after a disturbance. These 2 species always occupied different portions of the baits and did not come into conflict. P. floridana formed close aggregations at baits, while L. schaumi workers distributed themselves out sparsely on the bait. Individual L. schaumi workers, when met by individual S. invicta workers, would run quickly for a few centimeters and escape.

Camponotus nearcticus Emery, C. pennsylvanicus (DeGeer), and C. sayi Emery were on oaks and willows. Crematogaster clara Mayr had nests in fence posts in various parts of the farm. These species were seldom seen on the ground. Pseudomyrmina pallida F. Smith and Camponotus (Colobopsis) sp., ants which nest in hollow stems of perennial plants (Creighton 1950), were common in shrubbery along fencelines.

On 1 occasion, S. invicta was observed to take over an arboreal habitat. A tree was covered with the webbing of a psocid. Many flies and other insects were caught in the webbing. Trails of S. invicta extended up the tree through and under the webbing to a height of 6 meters.

The *S. invicta* workers collected dead insects from the webbing and took them down the tree. Curiously, occasional *S. invicta* workers were observed carrying material up the tree. Relatively few *Crematogaster ashmeadi* workers were observed on this tree. *S. invicta*, finding the tree a source of abundant food, may have overcome the other ant species. This observation served as further evidence that *S. invicta* prefers fixed food sources when available.

CONCLUSIONS

In 2 similar experiments, numbers of *S. invicta* were greatly reduced within 2 weeks of single treatments of pastures with mirex-bait at 4.26 grams per hectare (0.00375 pounds per acre) of active ingredient. The effectiveness of the treatment was not uniform. Following treatment, *S. invicta* populations were reduced for about 2 months, after which the treated area became repopulated by the ants. Numbers of a second predaceous ant taxon, *Nylanderia* spp., were also reduced by the treatment.

Numbers of Carabidae and various components of the epigeal spider community tended to increase in the mirex-treated areas. Higher numbers of horn fly pupae; plant bugs, *Trigonotylus pulcher* Reuter; chinch bugs, *Blissus insularis* (Say); parasitic wasps, *Apanteles* spp.; sarcophagid adults; pipunculid adults; and ant-like flower beetles, *Vacusus vicinus* (LaFerte) were detected in the mirex-treated areas, but these effects were inconsistent in the 2 experiments. A tentative explanation for these differences between treatments is that *S. invicta* may be a natural enemy of the above taxa, but is inconsistent in its effects upon populations.

Lower numbers of some spiders, Fulgoroidea, Dryinidae, flea-beetles, *Longitarsus* sp.; ambrosia beetles, *Xyleborinus saxeseni* (Ratzeburg); Staphylinidae, Aphodiinae, and Gryllidae were detected in the mirex-treated areas. These effects were apparently not severe and were inconsistent in the 2 experiments. The reduction in numbers of the last 3 taxa may indicate that mirex-bait applications may be detrimental to scavengers under some conditions.

An unknown portion of the material foraged by *S. invicta* likely consisted of dead and weakened arthropods. Live prey was probably so diverse that the impact of predation was ofen distributed in the community rather than concentrated on 1 species.

S. invicta appeared to act as a density governing factor that decreased horn fly pupae numbers when they were abundant under dung pats and hence easy to forage. Under these conditions, *S. invicta* reduced the numbers of Staphylinidae, probably mostly *Oxyteles* sp., concurrently with the horn fly pupae.

Ant species other than *S. invicta* shared the pasture habitat but occupied different niches and avoided conflict by various adaptations. *S. invicta* was occasionally active in the pasture trees.

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APPENDIX

Table 1. Mean numbers of selected taxa per collecting date in pitfall traps in mirex-treated and untreated pastures, Experiment 1, St. Gabriel, Louisiana.[1)]

Date	*Lycosa carolinensis*		*Lycosa rabida*		*Lycosa riparia-helluo* complex		*Schizocosa avida*		*Pardosa delicatula-milvina* complex	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 17	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.78	0.33
May 26	0.00	0.00	0.24	0.00	0.43	0.32	0.00	0.00	1.67	1.54
June 6	0.08	0.00	0.08	0.04	0.04	0.08	0.00	0.00	0.58	0.70
June 19	0.00	0.00	0.19	0.10	0.19	0.45	0.05	0.10	1.76	0.95
July 1	0.00	0.00	0.15	0.13	0.04	0.21	0.07	0.08	1.03	0.79
July 13	0.00	0.04	0.00	0.08	0.15	0.40	0.15	0.04	0.92	0.72
July 26	0.00	0.00	0.19	0.07	0.69	0.68	0.19	0.21	0.73	1.21
Aug 9	0.04	0.03	0.14	0.07	0.39	0.76	0.04	0.03	0.46	0.86
Aug 23	0.07	0.07	0.11	0.10	0.29	0.66	0.00	0.07	0.57	0.69
Sept 6	0.00	0.00	0.00	0.00	0.18	0.40	0.07	0.08	0.96	0.52
Sept 20	0.00	0.00	0.00	0.00	0.09	0.28	0.09	0.00	1.04	1.20
Oct 3	0.00	0.00	0.04	0.00	0.13	0.42	0.00	0.05	1.09	0.89
Oct 21	0.00	0.05	0.08	0.05	0.28	0.55	0.04	0.00	1.04	0.70
Nov 6	0.00	0.00	0.12	0.00	0.32	0.32	0.00	0.00	1.28	0.82

1) Mirex applied June 6.

2) Pitfall trap numbers for each collecting date shown in Appendix Table 3.

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

Table 1 (continued)

Date	*Pirata* spp.		Unidentified Lycosidae 4 to 8 mm. long		Unidentified Lycosidae Under 4 mm. long		*Trachelus deceptus*		Unidentified Araneae	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 17	0.11	0.00	2.89	1.33	2.67	1.00	0.00	0.00	4.89	2.50
May 26	0.00	0.00	5.43	7.45	0.00	0.00	0.95	0.73	0.24	1.50
June 6	0.00	0.00	3.50	5.67	0.79	0.00	0.17	0.29	4.04	4.79
June 19	0.42	0.25	3.95	3.60	1.09	0.70	0.57 *	0.10 *	3.48	2.15
July 1	0.00	0.00	3.11	1.70	1.15	0.75	0.04	0.12	2.30	1.38
July 13	0.04	0.00	2.73	2.44	2.00	1.20	0.46	0.20	1.88 *	3.16 *
July 26	0.11	0.07	1.69	2.61	2.04	1.61	0.31	0.46	3.65	3.21
Aug 9	0.07	0.14	1.68	2.45	1.61	1.79	0.57	0.55	2.75	2.76
Aug 23	0.04	0.07	1.75	2.20	1.07	1.48	0.46	0.64	3.32	3.17
Sept 6	0.07	0.04	1.39	3.24	0.75	0.92	0.29	0.32	2.57	4.44
Sept 20	0.26	0.04	1.65	3.08	0.61	0.92	0.30	0.92	2.83	3.32
Oct 3	0.00	0.11	0.78 *	1.68 *	1.43	1.47	0.48	0.58	5.74	3.58
Oct 21	0.04	0.25	0.80	0.85	0.56	0.75	0.68	1.30	4.28	3.00
Nov 6	0.08	0.18	0.52	1.00	0.76	1.00	0.56	0.91	2.40	1.55

Table 1 (continued).

Date	Chilopoda		Diplopoda		*Gryllus* spp.		Unidentified Gryllidae adults		Unidentified Gryllidae nymphs	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 17	0.11	0.00	0.00	0.00	0.11	0.00	1.11	0.00	0.22	1.17
May 26	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.32	0.00	0.00
June 6	0.00	0.33	0.00	0.00	0.03	0.00	0.96	0.54	0.08	0.04
June 19	0.05	0.00	0.00	0.00	0.11	0.04	0.76	1.10	0.05	0.05
July 1	0.04	0.00	0.00	0.04	0.03	0.05	0.37	0.42	0.37	0.29
July 13	0.00	0.00	0.00	0.00	0.12	0.14	0.23	0.12	0.80	0.40
July 26	0.15	0.07	0.04	0.07	0.54	0.90	0.35	0.43	1.04	1.32
Aug 9	0.04	0.03	0.00	0.00	0.80	1.10	0.29	0.24	3.21	3.69
Aug 23	0.07	0.00	0.00	0.00	1.80	1.27	0.11	0.24	3.29	4.03
Sept 6	0.00	0.00	0.00	0.00	0.96	0.10	0.39	0.12	3.53	4.44
Sept 20	0.00	0.00	0.00	0.00	1.30	0.92	0.61	0.68	2.52	4.68
Oct 3	0.13	0.10	0.00	0.00	2.90	1.50	0.65	0.21	4.74	4.05
Oct 21	0.08	0.00	0.00	0.05	0.21	0.15	0.20	0.15	1.36	1.75
Nov 6	0.16	0.23	0.16	0.23	0.00	0.00	0.00	0.05	1.56	1.09

Table 1 (continued).

Date	*Euborellia annulipes*		*Labidura riparia*		*Megacephala virginica*		Carabidae		Staphylinidae	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 17	0.22	0.17	0.00	0.00	0.00	0.00	0.67	0.17	2.67	1.00
May 26	0.00	0.04	0.00	0.00	0.00	0.00	0.05	0.09	0.43	0.59
June	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.22	0.88	1.17
June 19	0.00	0.15	0.00	0.00	0.23	0.40	0.10	0.00	2.91	2.70
July 1	0.59	0.00	0.00	0.00	0.37	0.75	0.04	0.00	0.44	0.75
July 13	0.27	0.00	0.08	0.00	0.38	0.32	0.04	0.00	0.85	0.48
July 26	0.08	0.07	0.00	0.00	0.65	0.21	0.08	0.04	2.80	1.68
Aug 9	0.12	0.21	0.00	0.00	0.29	0.17	0.04	0.07	1.32	0.86
Aug 23	0.25	0.52	0.00	0.00	0.07	0.00	0.11	0.21	1.29	1.21
Sept 6	0.14	0.24	0.00	0.36	0.00	0.00	0.11	0.92	0.93	0.64
Sept 20	0.48	2.00	0.00	0.00	0.00	0.00	0.17	0.32	1.87	1.80
Oct 3	3.61	1.58	0.43	0.16	0.00	0.00	0.00	0.37	2.96	2.53
Oct 21	0.92	1.05	0.00	0.00	0.00	0.00	0.24	0.30	0.76	0.80
Nov 6	1.24	0.27	0.00	0.00	0.00	0.00	0.16	0.14	1.08	0.50

Table 1 (continued).

Date	*Monotoma picipes*		*Ahasverus rectus*		*Vacusus vicinus*		*Euethiola rugiceps*	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 17	0.11	0.00	1.33	0.00	1.11	1.00	0.11	0.17
May 26	0.48	0.00	1.62	0.09	0.67	0.77	0.00	0.09
June 6	0.00	0.00	0.21	0.08	0.13	0.25	0.00*	0.17*
June 19	0.00	0.00	0.10	0.00	0.81	0.55	0.05	0.10
July 1	0.07	0.04	3.07	0.67	1.70	1.46	0.00	0.00
July 13	1.12	0.12	0.38	0.32	2.38	2.04	0.00	0.00
July 26	0.58	0.50	2.34	2.36	4.65	6.21	0.00	0.00
Aug 9	0.68	1.41	4.11	2.86	5.86	9.03	0.00	0.17
Aug 23	0.68	0.24	4.07	5.38	3.82*	8.41*	0.00	0.00
Sept 6	0.43	1.44	2.39	4.08	4.71	10.08	0.00	0.04
Sept 20	0.39	0.64	4.43	4.80	1.39*	4.52*	0.00	0.00
Oct 3	0.23	0.11	5.13	3.21	2.83	7.95	0.09	0.00
Oct 21	0.00	0.00	0.16	0.35	0.84	1.35	0.00	0.05
Nov 6	0.00	0.00	0.28	0.14	0.48	1.64	0.00	0.00

Table 1 (continued).

Date	*Aphodius lividus*		Aphodiinae		*Xyleborinus saxeseni*		*Sphenophorus* spp.		*Spodoptera frugiperda*	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 17	0.00	0.00	0.44	0.00	2.78	2.17	0.22	0.00	0.00	0.00
May 26	0.00	0.00	0.19	0.05	2.33	3.59	0.05	0.00	0.00	0.00
June 6	0.00	0.00	0.00	0.04	1.38	1.75	0.00	0.00	0.00	0.00
June 19	0.05	0.00	0.09	0.05	0.90	1.05	0.05	0.05	0.05	0.00
July 1	0.04	0.00	0.11	0.04	0.55	0.08	0.07	0.00	0.04	0.04
July 13	0.12	0.56	0.11	0.28	1.04	0.44	0.00	0.04	0.04	0.00
July 26	0.27	0.21	0.81	0.93	2.69	2.50	0.04	0.11	0.04	0.00
Aug 9	0.00	0.00	0.57	0.93	3.93	2.31	0.18	0.07	0.14	0.17
Aug 23	0.00	0.10	0.50	0.52	1.75	1.45	0.10	0.31	0.39	0.86
Sept 6	0.07	0.04	0.29	0.24	0.32*	0.96*	0.14	0.13	0.25	0.08
Sept 20	0.00	0.00	0.00	0.00	0.26	1.24	0.09	0.30	0.22	0.33
Oct 3	0.61	0.00	0.68	0.16	0.09	0.11	0.23	0.16	0.04	0.05
Oct 21	0.64*	0.00*	0.76*	0.00*	0.96	1.20	0.04	0.00	0.08	0.05
Nov 6	0.76	0.05	0.88	0.04	0.04	0.00	0.00	0.00	0.28	0.05

Table 1 (continued).

Date	*Nylanderia* spp.		*Hypoponera opaciceps*		*Cyphomyrmex rimosus*		*Solenopsis invicta*	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 17	0.55	0.00	0.00	0.00	0.11	0.00	6.77	5.50
May 26	2.09	0.18	0.00	0.00	0.00	0.00	12.67	16.82
June 6	0.96	0.22	0.00	0.08	0.00	0.00	16.67	16.40
June 19	0.48	0.10	0.05	0.05	0.00	0.00	10.42**	1.15**
July 1	0.44	0.00	0.00	0.00	0.00	0.00	11.03**	1.58**
July 13	0.50	0.40	0.15	0.08	0.00	0.04	24.50**	0.64**
July 26	0.50	0.11	0.11	0.11	0.04	0.00	15.38**	1.96**
Aug 9	0.43	0.03	0.07	0.00	0.04	0.00	11.93*	2.27*
Aug 23	0.74	0.00	0.00	0.07	0.00	0.00	11.75**	1.10**
Sept 6	0.14	0.00	0.14	0.12	0.00	0.00	4.29**	2.72**
Sept 20	0.26*	0.00*	0.04	0.00	0.00	0.00	4.13	4.44
Oct 3	0.17	0.00	0.73	0.16	0.04	0.00	8.43	9.00
Oct 21	0.20	0.25	0.08	0.25	0.04	0.10	8.20	5.60
Nov 6	0.00	0.05	0.08	0.18	0.00	0.09	3.28	0.82

Table 2. Mean numbers of selected taxa per collecting date in pitfall traps in mirex-treated and untreated pastures, Experiment 2, St. Gabriel and Ben Hur Farm, Louisiana.[1) 2)]

Date	*Lycosa carolinensis*		*Lycosa rabida*		*Lycosa riparia-helluo* complex		*Schizocosa avida*		*Pardosa delicatula-milvina*	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 15	0.00	0.00	0.00	0.00	0.38	0.44	0.00	0.00	0.00	0.00
May 24	0.00	0.00	0.00	0.00	0.75	0.25	0.00	0.00	0.25	1.25
June 1	0.13	0.00	0.00	0.00	0.13	0.50	0.00	0.00	0.13	0.20
June 8	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	1.00	1.25
June 15	0.00	0.00	0.00	0.00	0.25	0.08	0.08	0.00	1.25	0.17
June 22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.25
June 30	0.00	0.00	0.00	0.00	0.10	0.67	0.00	0.00	0.30	0.17
July 6	0.00	0.00	0.00	0.00	0.50	0.25	0.00	0.00	1.75	0.75
July 15	0.00	0.00	0.13	0.06	0.27	0.27	0.07	0.00	1.20	0.80
July 20	0.00	0.00	0.14	0.13	0.07	0.00	0.14	0.00	2.29	2.06
Aug 1	0.00	0.08	0.13	0.25	0.93	0.58	0.00	0.00	1.53	1.83
Aug 10	0.13	0.07	0.00	0.20	0.37	0.47	0.19	0.07	0.75	0.87
Aug 17	0.07	0.00	0.13	0.00	0.13	0.40	0.13	0.06	0.80	0.46
Aug 24	0.13	0.00	0.00	0.06	0.38	0.37	0.19	0.00	1.13	0.94
Sept 1	0.00	0.00	0.07	0.00	0.33 *	0.06 *	0.60 *	0.00 *	1.13	1.38
Sept 17	0.00	0.00	0.00	0.00	0.33	0.83	0.00	0.17	0.00	0.17
Sept 26	0.00	0.22	0.00	0.00	0.08	0.00	0.08	0.00	1.58 *	0.44 *

1) Mirex applied in late May and early June (dates for each pasture shown in Table 3).

2) Pitfall trap numbers for each collecting date shown in Appendix table 3.

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

Table 2 (continued).

Date	*Pirata* spp.		Unidentified Lycosidae 4 to 8 mm. long		Unidentified Lycosidae Under 4 mm. long		*Trachelus deceptus*		Unidentified Araneae	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 15	0.00	0.00	0.50	1.11	0.13	0.00	0.00	0.22	0.88	1.00
May 24	0.00	0.25	1.75	7.25	0.75	0.50	0.50	0.00	2.75	6.25
June 1	0.00	0.00	0.00*	1.00*	0.13	0.10	0.00	0.10	1.00	2.30
June 8	0.25	0.00	8.50	3.25	0.25	0.25	0.00	0.25	10.25	3.00
June 15	0.08	0.00	2.42	1.80	0.50*	1.25*	0.08	0.50	2.41	3.00
June 22	0.00	0.00	19.50	7.25	3.00	0.75	0.75	0.75	2.75	4.00
June 30	0.00	0.00	1.00	0.67	0.40	0.50	0.30	0.91	1.80	3.00
July 6	0.00	0.00	8.00	10.00	2.25	3.25	0.75	1.50	3.25	7.75
July 15	0.00	0.00	2.40	3.60	1.53	1.27	0.27	0.53	1.73	1.80
July 20	0.14	0.00	3.79	6.13	1.57	1.53	0.36	0.60	1.14	1.60
Aug 1	0.33	0.25	4.00	4.08	4.20	4.08	0.40	1.67	3.67	3.50
Aug 10	0.12	0.33	1.88	1.93	2.88	1.80	0.56	0.67	2.75	3.20
Aug 17	0.20	0.13	2.40	0.93	1.33	1.60	0.22	0.40	1.73	0.93
Aug 24	0.25	0.13	2.18	1.38	1.13*	2.94*	0.00*	0.56*	3.19	2.25
Sept 1	0.00*	0.25*	1.53	3.19	1.33	1.94	0.73	1.69	4.07	2.25
Sept 17	0.00	0.33	0.33	0.33	1.33	2.50	0.00	0.33	0.67	1.67
Sept 26	0.08	0.00	3.50	0.56	1.17	2.11	0.08	0.33	2.42	1.22

Table 2 (continued)

Date	Chilopoda		Diplopoda		Gryllus spp.		Unidentified Gryllidae adults		Unidentified Gryllidae nymphs	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 15	0.13	0.00	0.00	0.00	0.75	0.11	0.00	0.00	0.13	0.00
May 24	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00
June 1	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.63	0.00
June 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00
June 15	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.33	0.08
June 22	0.25	0.00	0.00	0.00	0.00	0.00	3.25	1.25	0.50	0.00
June 30	0.00	0.00	0.00	0.00	0.10	0.00	0.10	0.00	3.30	0.42
July 6	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.50	0.50
July 15	0.26	0.20	0.07	0.00	0.73*	0.06*	0.93	0.47	0.80	0.07
July 20	0.00	0.00	0.00	0.00	0.21	0.06	2.14	0.67	0.50	0.20
Aug 1	0.20	0.00	0.00	0.00	1.07	1.63	3.40	1.31	5.06	4.43
Aug 10	0.00	0.00	0.00	0.00	1.63	0.60	1.31	0.60	4.44	3.53
Aug 17	0.00	0.07	0.00	0.00	0.80	0.67	1.40	0.67	3.67	4.20
Aug 24	0.19	0.00	0.00	0.00	1.63	0.73	0.44	0.56	5.19	5.12
Sept 1	0.00	0.06	0.00	0.00	3.07*	0.63*	0.93	0.69	4.33	4.69
Sept 17	0.33	0.00	0.00	0.00	6.33	1.50	1.00*	0.17*	2.67*	10.33*
Sept 26	0.00	0.00	0.00	0.00	1.08	0.00	0.75	0.22	0.67	0.88

Table 2 (continued).

Date	*Euborellia annulipes*		*Labidura riparia*		*Megacephala virginica*		Carabidae		Staphylinidae	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 15	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.44	0.13	0.33
May 24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00
June 1	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.10
June 8	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.75	0.00
June 15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00
June 22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00
June 30	0.00	0.00	0.00	0.00	0.00	0.08	0.10	0.08	0.90	0.08
July 6	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.25	0.00	0.53
July 15	0.00	0.00	0.00	0.00	0.00	0.06	0.20	0.13	0.53	0.67
July 20	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.13	0.29	0.27
Aug 1	0.07	0.17	0.00	0.00	0.20	0.00	0.20*	1.08*	2.40	1.17
Aug 10	0.25	0.07	0.00	0.00	0.00	0.00	0.06	0.73	0.93	0.60
Aug 17	0.13	0.27	0.00	0.00	0.07	0.00	0.00	0.00	1.87	0.73
Aug 24	0.00	0.19	0.00	0.00	0.06	0.06	0.00*	0.25*	2.18	1.19
Sept 1	0.13	0.37	0.00	0.00	0.00	0.00	0.33	0.25	1.40	1.06
Sept 17	0.00	1.00	0.00	0.00	0.00	0.00	0.67	0.17	3.67	2.50
Sept 26	0.00	0.11	0.00	0.00	0.08	0.00	0.00	0.11	0.75	0.67

Table 2 (continued).

Date	Monotoma picipes		Ahasverus rectus		Vacusus vicinus		Euethiola rugiceps	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 15	0.00	0.00	0.00	0.11	0.50	0.11	0.13	0.00
May 24	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
June 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June 15	0.00	0.00	0.08	0.00	0.00 *	0.33 *	0.08	0.08
June 22	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
June 30	0.00	0.08	0.00	0.00	0.10	0.42	0.00	0.08
July 6	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25
July 15	0.13	0.07	0.00	0.73	0.67	0.60	0.00	0.00
July 20	0.50	1.13	0.50	0.20	2.00	0.46	0.14	0.00
Aug 1	0.73	1.00	1.46	0.92	3.53	5.67	0.00	0.00
Aug 10	1.13	1.40	0.63 *	0.07 *	5.31	3.60	0.06	0.00
Aug 17	0.80	1.13	1.06	0.27	3.20	3.00	0.00	0.06
Aug 24	0.81	0.68	0.56	0.25	5.06	4.88	0.00	0.00
Sept 1	0.47	0.37	1.47 *	0.19 *	3.93	2.94	0.07	0.00
Sept 17	0.00	1.00	1.00	0.50	2.00	7.83	0.00	0.33
Sept 26	0.00	0.00	0.91	0.22	1.00	0.55	0.08	0.11

Table 2 (continued)

Date	*Aphodius lividus*		Aphodiinae		*Xyleborinus saxeseni*		*Sphenophorus* spp.		*Spodoptera frugiperda*	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
May 24	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
June 1	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00
June 8	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June 15	0.00	0.08	0.00	0.08	0.00	0.00	0.08	0.17	0.00	0.08
June 22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June 30	0.80	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July 6	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.25	0.25	0.00
July 15	0.00	0.07	0.00	0.33	0.13	0.13	0.00	0.00	0.07	0.07
July 20	0.07	0.07	0.07	0.07	0.36	0.36	0.00	0.00	0.07	0.07
Aug 1	0.27	0.00	0.80	0.50	1.47	1.00	0.00	0.00	0.20	0.08
Aug 10	0.06	0.00	0.31	0.13	3.38	0.93	0.00	0.00	0.50	0.20
Aug 17	0.00	0.07	0.33	0.13	2.40	0.47	0.00	0.00	0.20	0.07
Aug 24	0.00	0.13	0.81	0.31	1.81	0.31	0.13	0.12	0.13	0.12
Sept 1	0.06	0.06	0.33	0.38	1.33	1.06	0.13	0.13	0.20	0.44
Sept 17	0.00	0.00	0.00	0.00	0.33	0.17	0.00	0.67	0.00	0.67
Sept 26	0.25	0.11	0.25	0.11	0.00	0.22	0.17	0.00	0.00	0.00

Table 2 (continued).

Date	*Nylanderia* spp.		*Hypoponera opaciceps*		*Cyphomyrmex rimosus*		*Solenopsis invicta*	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
May 15	0.13	0.33	0.00	0.00	0.00	0.00	11.75	20.11
May 24	0.00	0.00	0.00	0.00	0.00	0.00	8.00	5.25
June 1	0.00	0.10	0.00	0.00	0.00	0.00	5.75	3.80
June 8	0.25	0.00	1.00	0.00	0.00	0.00	7.50	3.00
June 15	0.50	0.16	0.00	0.00	0.00	0.00	6.83**	0.58**
June 22	1.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00
June 30	1.20	0.08	0.00	0.00	0.00	0.00	17.50**	0.17**
July 6	0.25	0.00	0.00	0.00	0.00	0.00	9.25	0.00
July 15	1.06	0.00	0.00	0.00	0.00	0.00	18.67**	0.27**
July 20	3.36	0.00	0.07	0.00	0.00	0.00	24.86**	1.07**
Aug 1	1.33	0.00	0.07	0.00	0.00	0.00	22.20**	2.42**
Aug 10	1.25	0.00	0.06	0.00	0.00	0.07	21.94**	4.20**
Aug 17	0.20	0.07	0.00	0.07	0.00	0.00	11.60**	2.47**
Aug 24	0.63	5.06	0.25	0.06	0.00	0.00	19.13*	6.81*
Sept 1	2.20	0.06	0.66	0.12	0.00	0.00	21.53	11.25
Sept 17	0.00	0.16	0.33	1.00	0.00	0.00	4.33	3.95
Sept 26	0.67	0.00	0.75	0.00	0.00	0.00	8.08	3.22

Table 3. Numbers of pitfall trap samples collected each collecting date in Experiments 1 and 2.

Date	Untreated Pastures	Treated Pastures	Date	Untreated Pastures	Treated Pastures
May 17	9	8	May 15	7	7
May 26	29	30	May 24	4	4
June 6	30	30	June 1	7	10
June 19	28	24	June 8	4	4
July 1	26	22	June 15	12	12
July 13	26	28	June 22	4	4
July 26	28	29	June 30	10	11
Aug 9	30	29	July 6	4	4
Aug 23	30	29	July 15	15	15
Sept 6	28	25	July 20	14	14
Sept 20	23	25	Aug 1	16	12
Oct 3	22	21	Aug 10	16	15
Oct 21	25	20	Aug 17	14	16
Nov 6	25	22	Aug 24	16	16
			Sept 1	15	16
			Sept 17	3	5
			Sept 26	12	9

Table 4. Paired cattle dung pat samples from pastures 110 and 210, Experiment 2 (1973), St. Gabriel, Louisiana. Dates and hours defecated, weights and dimensions of dung pats, and numbers of hours exposed in field.

Pair	Date	Hour Dung Pat Defecated [1]		Weight of Dung Pat (grams)		Dimensions of Dung Pat (Cm.)		Number of hours Exposed in Field	
		Untr. Area	Mirex-Tr. Area	Untr. Area	Mirex-Tr. Area	Untr. Area	Mirex-Tr. Area	Untr. Area	Mirex-Tr. Area
1	June 21	15.25	16.00	321	323	20X20	10X20	114.3	114.8
2	21	15.25	16.00	730	669	25X25	23X23	114.4	112.0
3	22	15.75	16.75	2059	2202	20X20	------	139.8	139.3
4	24	15.50	15.75	1261	1009	30X30	23X23	95.8	95.6
5	26	10.25	10.25	227	808	19X29	25X30	149.5	148.6
6	26	16.25	16.75	276	1257	28X28	30X30	143.5	144.9
7	28	11.75	12.25	287	1306	30X30	30X30	123.7	122.8
8	29	15.00	15.50	502	857	24X32	30X30	145.5	144.9
9	29	16.75	16.50	115	130	9X 9	7X 7	145.5	145.1

1) 15.25 hours = 3:15 P.M., etc.

Table 5. Paired cattle dung pat samples from pasture 110 and 210, Experiment 2 (1973), St. Gabriel, Louisiana, showing numbers of specimens of selected insect categories per pat.

Pair	Haematobia irritans (pupae)		Staphylinidae			
			Philonthus spp.		Other species	
	Untr. Area	Mirex-Tr. Area	Untr. Area	Mirex-Tr. Area	Untr. Area	Mirex-Tr. Area
1	0	21	0	1	0	1
2	12	39	15	7	2	17
3	1	50	0	5	0	45
4	32	12	26	4	4	14
5	8	69	0	0	0	0
6	2	52	2	14	0	36
7	1	16	0	2	0	0
8	11	70	0	11	0	29
9	0	1	0	0	0	0

Pair	Sarcophagidae		Phelister haemorrous		Aphodiinae	
	Untr. Area	Mirex-Tr. Area	Untr. Area	Mirex-Tr. Area	Untr. Area	Mirex-Tr. Area
1	3	7	3	3	34	7
2	3	5	10	4	148	23
3	0	0	2	9	13	22
4	6	1	6	3	20	11
5	2	6	0	0	4	4
6	18	9	2	38	2	1
7	20	34	0	2	2	30
8	12	1	5	6	11	3
9	1	1	0	0	3	0

VITA

Forrest William Howard was born in Denver, Colorado, on February 8, 1936, the son of Dr. and Mrs. Forrest H. Howard. He completed most of his primary and secondary education in Rochester, New York. He was graduated from West High School of that city in 1954, after which he entered the New York State College of Forestry in Syracuse, New York. He received the degree of Bachelor of Science from that Institution in 1961. In addition to serving in the U.S. Army, he worked as the assistant to a forest entomologist in Mississippi, and as a professional forester in Brazil, California, and Florida. During the last four years prior to entering graduate studies he was employed as a biologist with the Bureau of Entomology of the Florida Board of Health, working in ecological studies of coastal marshes. In 1966 he was married to Gloria Cecilia Cleves, of Ibague, Colombia. Their daughter, Andrea, was born in 1968. He began graduate studies in the Department of Entomology of Louisiana State University in January, 1970, and received the Master of Science degree in December, 1971. He has been employed as an Associate in the Department of Entomology since January, 1972, and is presently a candidate for the degree of Doctor of Philosophy.

EXAMINATION AND THESIS REPORT

Candidate: Forrest William Howard

Major Field: Entomology

Title of Thesis: Arthropod Population Dynamics in Pastures Treated with Mirex-Bait to Suppress Red Imported Fire Ant Populations

Approved:

R. D. Oliver

Major Professor and Chairman

James G. Traynham

Dean of the Graduate School

EXAMINING COMMITTEE:

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Date of Examination:

May 15, 1975